MANUAL OF PUBLIC HEALTH

FOR

IRELAND.

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CONTENTS.

EDITOR'S PREFACE.

The passing of "The Public Health (Ireland) Act, 1874," marks a new era in the history of the Sanitary Administration of this country. The Local Authorities and the Sanitary Officers under the Act have been entrusted with the performance of duties which are numerous, responsible, and novel. Upon no class of Officers have devolved more responsible functions than upon the Dispensary Medical Officers, who by section 10 of the Act have been appointed *ex-officio* Sanitary Officers. It must be remembered also that the wide distinction which exists between the Local Authorities and Officers of Ireland and those of England as to allotment of districts, performance of duties, and assignment of emoluments, necessitates the laying down of a special code of regulations for the respective countries. It was with a keen appreciation of this circumstance that the compilation of the present work was undertaken.

A "Manual of Public Health for Ireland" became a necessity on the passing of the new Act; but it was never intended to supersede the many excellent text-books or manuals on Preventive Medicine and Hygiene which have recently been published in England. At the same time, the authors, while endeavouring to make

the Manual as complete as possible in its relation to local matters, have aimed at incorporating in the work a well considered digest of the ablest writings on State Medicine. Thus, in addition to a summary and index of Irish Sanitary Statutes, the following subjects, which have more than a local bearing, are treated of—the Sanitary Duties of Authorities and Officers, Vital Statistics, the Conditions necessary to Public Health, Preventable Disease, Etiology of Disease, Food, Water Supply, Examination of Water, House Construction, Drainage and Sewerage, Air and Ventilation, Hospital Accommodation, Disinfection, Climate, and Meteorology.

It is right to mention that in several of the Chapters the authors have extensively made use of lectures which were delivered by themselves in the Theatre of the Royal Dublin Society in the Spring of 1873. They also desire to acknowledge their indebtedness to the Registrars-General of England, Scotland, and Ireland; and to the classical writings of Dr. Parkes, F.R.S., Professor of Military Hygiene in the Army Medical School, Netley; Mr. Simon, F.R.S., Medical Officer of the Local Government Board, England, and his able coadjutors, the Medical Inspectors of that Board; Dr. Charles Murchison, F.R.S.; and M. Ad. Quetelet, Directeur de l'Observatoire Royale de Bruxelles. Lastly, they have to thank Mr. Bridgeford, of this city, for some useful hints on points relating to House Construction.

The unavoidable delay which has occurred in the publication of this Manual is a matter of sincere regret to the authors, but the many interruptions to which the literary labours of professional men are subject, must be their apology to the Subscribers and to the Public.

JOHN WILLIAM MOORE, M.D.

40, Fitzwilliam-square, West,
Dublin, *January 6, 1875.*

The authorities constituted by the Act were as follows:—

1. In Cities and Towns Corporate—*The Corporation.*
2. In Towns and Townships—The "*Town*," "*Township*," "*Lighting and Cleansing*," or "*Municipal Commissioners*," as the case might be.
3. In such part of each Union as was not under another Sewer or Nuisance Authority—*The Poor Law Guardians.*

These various bodies were entrusted with the double functions of Sewer Authorities under the Sewage Utilization Act, 1865, and of Nuisance Authorities under the Nuisance Removal Acts.

Thus, for ordinary purposes of sanitary administration, "every part of Ireland was placed under some single and known jurisdiction."

The Boards of Guardians were in every case constituted the "*Local Authorities*" for executing the provisions of the Diseases Prevention Act, when in force.

With regard to certain matters, the Lord Lieutenant, the Privy Council, the Chief Secretary to the Lord Lieutenant, and the Poor Law Commissioners for Ireland, were given powers of control over the action of the local bodies. In 1872 these powers were transferred to the Local Government Board for Ireland, by the 35 & 36 Vict., c. 69.

The Public Health (Ireland) Act, 1874, has largely increased the powers of the Board as Controlling Sanitary Authority, and has effected several important changes in the constitution and powers of the local authorities.

In a circular, recently issued by the Local Government Board, the following are stated to be the principal changes introduced by the Act:—

"1. A better arrangement of the Sanitary Districts and Sanitary Authorities by the Act itself.

"2. A power given to the Local Government Board to organise the machinery for the administration of the Sanitary Law within each Sanitary District, and to exercise a control over its management, which previously it could not exercise, even in relation to Boards of Guardians, far less in relation to the various municipalities.

"3. A power given to the Sanitary Board, subject to the consent of the Local Government Board, to remunerate Local Officers for additional obligations cast upon them under the Sanitary Law, and to determine the emoluments of any new Officers whom it may be found necessary to appoint; additional expenses, so incurred, to be borne (probably to the extent of one-half, as in England,) by the Imperial Exchequer."

The principal provisions of the Act will be noticed in detail.

A.—Provisions relating to Urban and Rural Sanitary Districts and Authorities.

The Act, following the precedent of The Public Health Act, 1872, for England, has divided Ireland into *Urban* and *Rural* "*Sanitary Districts*," governed respectively by *Urban* and *Rural* "*Sanitary Authorities.*" (Sec. 2.)

Sanitary Districts.—The Sanitary Districts are the same as the Sewer and the Nuisance Districts created by the Sanitary Act, 1866, with this important restriction—that towns (other than corporate towns, or towns or townships having Commissioners under Local Acts), the population of which, according to the last census (1871), *does not exceed* 6,000, are not retained as Urban Districts, but are included in the Rural Sanitary Districts within which they are situated.

In consequence of this restriction, the number of Urban Sanitary Districts has been reduced from 111 to 42.

The number of Rural Districts continues the same as it was under the Act of 1866, *i.e.*, 163; of these, 129 Districts consist of entire Unions, and 34 of parts of Unions, of which other parts are Urban Districts.

A Table showing the various Urban and Rural Sanitary Districts in Ireland will be found in Appendix I.

Sanitary Authorities.—The "Sanitary Authorities" are

the same as under the Act of 1866, *i.e.*, in Urban Districts—*The Corporation or Commissioners;* and, in Rural Districts—*The Poor Law Guardians.* (Secs. 3, 4.)

In the case of a Union, any portion of which is included in an Urban Sanitary District, the following important provisoes must be borne in mind:—

1. If any electoral division of the union forms, or is *wholly* included within an Urban Sanitary District, the elective guardians of such division cannot act or vote on sanitary matters. (Sec. 4.)
2. If part of any electoral division forms, or is situated in an Urban Sanitary District, the Local Government Board may, by order, divide such electoral division into wards, and determine the number of guardians to be elected by such wards, respectively, so as to provide for the due representation of the part of the division which lies within the Rural Sanitary District Until such order, the guardians of such electoral division may act and vote on sanitary matters. (Sec. 4.)
3. An *ex-officio* guardian resident in any part of an electoral division, included in an Urban Sanitary District, cannot so act or vote, unless he has sufficient property in the rural part of the district to qualify him as an elective guardian. (Sec. 4.)

Under the Sanitary Act, 1866, sec. 4, a Sanitary Authority may delegate its powers to a Committee consisting wholly of its own members, or partly of its own members and partly of ratepayers not members of the Authority.

Sanitary Officers.—The provisions of the Act relating to this subject will be found in Chapter II.

Alteration of Districts.—The Local Government Board may, by provisional order, separate from a Rural Sanitary District any town wholly situate therein, containing upwards of 6,000 inhabitants, and may either constitute it a new

Urban Sanitary Distrct, or include it in any adjoining Urban Sanitary District.

The Board may likewise, by provisional order, add any Urban Sanitary District to the Rural District in which it is situated.

In each case the provisional order can be made only upon petition from the town, township, or district. (Sec. 5.)

Transfer of Powers and Duties to Sanitary Authorities.—All powers, duties, and liabilites of

"The *Sewer* Authority," under the Sewage Utilization Acts,

"The *Nuisance* Authority," under the Nuisance Removal Acts,

"The *Local* Authority," under the Common Lodging House Acts, Artizans and Labourers Dwellings Act, and the Bake-House Regulation Act,

as amended by any General or Local Act, or Provisional Order, in force within the district of a Sanitary Authority, are transferred to such Authority exclusively.

In every Urban Sanitary District, the Urban Sanitary Authority shall, subject to the provisions of the Act, continue to act in execution of any general or local Act or provisional order in force within such district immediately before the passing of the Act, and in the execution of which, at such time, the body, by the Act constituted Urban Authority, was acting.

In any Rural Sanitary District all powers, rights, duties, &c., with respect to sanitary matters, under any general or local Act or provisional order, in force within such district, or any part thereof, immediately before the passing of the Act, shall be transferred to the Rural Sanitary Authority of such district, to the exclusion of any other authority which may have previously exercised, or been subject to the same powers, &c.

All Sanitary Authorities are also entrusted with the powers belonging to the persons acting in the execution of the

Baths and Wash-Houses Act, and the Labouring Classes Lodging Houses Acts, if these Acts are in force within their district. If they are not, the Sanitary Authority may adopt them. (Sec. 7.)

Diseases Prevention Act.—The Boards of Guardians are retained as the "Local Authorities" under the Diseases Prevention Act. All expenses incurred under the Act are to be defrayed out of the poor rates. (Sec. 8.)

Transfer of Property to Sanitary Authorities.—All property belonging to the various bodies whose powers are transferred to the Sanitary Authorities, is vested in such Authorities, to be held by them in trust for the district or place within their jurisdictions, for the benefit of which such property was held previously to the transfer. (Sec. 9.)

Settlement of Differences.—The Local Government Board, on the application of any Authority from, or to whom, any powers, rights, property, &c., are transferred in pursuance of the Act, may settle any differences and adjust any accounts incidental to such powers, &c., or the transfer thereof. (Sec. 35.)

Expenses.—Expenses are to be defrayed as follows:—

1. *Urban Sanitary Authority.*
   (*a*). In the case of a *Town Council*—
   Out of the borough rate or fund.
   (*b*). In the case of *Commissioners*—
   Out of any rate leviable by them as such Commissioners throughout the whole of their district.

Where an Urban Sanitary Authority had power before the passing of the Act to levy throughout the whole of its district, a rate for paving, sewering, or other sanitary purposes, its expenses under the Act are to be paid out of such rate or rates, except where at the time of the passing

of the Act any part thereof was chargeable upon the borough rate or fund, in which case they are to continue so chargeable. The Local Government Board may, by provisional order, alter the incidence of such charge. (Sec. 12.)

2. *Rural Sanitary Authority.*

Expenses of Rural Sanitary Authorities are of two kinds, *General* and *Special.*

a. General Expenses.—Other than those chargeable upon owners and occupiers under the Sanitary Acts (*i.e.*, private improvement expenses).

(α.) Cost of establishment and officers.

(β.) Expenses not declared to be special by the Act, or by order of the Local Government Board.

b. Special Expenses.

(α.) Cost of construction, maintenance, and cleansing of sewers in any contributory place within the district.

(β.) Providing water supply to contributory place.

(γ.) Lighting where authorised.

(δ.) Expenses incurred in relation to property transferred to the Authority, in trust for any district or contributory place.

(ε.) All other expenses payable by the authority in respect of any contributory place within its district, and declared by order of the Local Government Board to be Special.

Expenses of constructing and maintaining sanitary works for the common benefit of two or more contributory places, may be apportioned by the Sanitary Authority, and be deemed special expenses in respect of such contributory place, subject to the right of the ratepayers of such place to appeal to the Local Government Board against such apportionment.

General Expenses are to be defrayed out of a common fund to be raised out of the poor rate of the electoral divisions, or parts thereof comprised in the Sanitary District, according to the rateable value of each such division, or part thereof.

The Act is silent as to the manner in which these expenses are to be raised.

Special Expenses are to be a charge on some contributory place or places, within the district.

The Local Government Board are empowered to determine on what area of charge, being a contributory place, or consisting of contributory places, any special expenses shall be chargeable. Special expenses are to be raised by means of a special poundage rate, to be added to the poor rate on the contributory places on which such expenses are charged.

Contributory Places.—The following areas are constituted contributory places.

(1.) The Dispensary District.
(2.) The Electoral Division.
(3.) The Townland. (Secs. 13, 14.)

The average area of a Union is 124,679 statute acres. The average net annual value, £80,696. The average population, 35,574. Each Union contains on the average five Dispensary Districts, each with an average population of about 8,000. The total number of Electoral Divisions in Ireland is 3,438, giving an average of about 21 to each Union. The average population of each Electoral Division is 1,686, and the average acreage 5,900 statute acres. The Townland (of which there are about 60,000 in Ireland) is the territorial unit for Poor Law and Sanitary purposes.

Audit of Accounts.—The accounts of every Sanitary Authority are to be audited by an Auditor of the Local Government Board, whose powers with respect to such accounts are the same as in the case of the audit of the accounts of the governing bodies of towns, under the Local Government (Ireland) Act, 1871. Fourteen days' notice of audit is sufficient. (Sec. 49.)

B.—Provisions relating to Union of Districts.

United Districts.—The Local Government Board may, by provisional order, on the application of one or more of the

Sanitary Authorities of any districts, form such districts or any parts thereof, or any contributory places in a Rural District or Districts, into a United District, for all or any of the following purposes, viz:—

(1.) Procuring a common water supply.

(2.) Making a main sewer, or carrying out a system of sewerage.

(3.) Any other purposes of any of the Sanitary or Burial Grounds Acts. (Sec. 19.)

The Expenses incurred in the formation of a United District shall be a first charge on the rates leviable in the United District under the Act. (Sec. 20.)

Joint Board.—The governing body of a United District shall be a Joint Board, consisting of such *ex-officio* and elective guardians as the Local Government Board may determine. (Sec. 21.)

The powers, rights, and duties of the Joint Board shall be defined by the provisional order constituting the district.

Upon the formation of a Joint Board, the Sanitary Authorities, of the districts or contributory places included in the United District, shall cease to exercise or perform therein any powers or duties which are transferred to the Joint Board.

The Joint Board, however, may delegate to the Sanitary Authority of any component district, the exercise of any of its powers for the performance of any of its duties, with the approval of the Local Government Board. (Sec. 22.)

The Expenses of a Joint Board, unless otherwise determined by the provisional order, are to be defrayed out of a common fund to be contributed by the component districts or contributory places, in proportion to the rateable value of the property in each district or place. (Sec. 23.)

Use of Sewer of Subjacent District.—A Sanitary Authority, by agreement with the Authority of a subjacent district, and with the sanction of the Local Government Board, may cause the sewers of its district to communicate, for the purpose of outfall, with the sewers of the subjacent district; and may

enter into an arrangement with the Authority of that district for the disposal, etc., of the sewage of such first-mentioned district. (Sec. 25.)

C.—Repeal, etc., of Local Acts.

The Local Government Board, on the application of the Sanitary Authority of any district, may, by provisional order, repeal, either wholly or partially, or alter local Acts relating to sanitary matters, and may increase or diminish the area to which such Acts shall apply. (Sec. 26.)

D.—Provisions relating to the acquisition of, and dealings with, Land, etc., by Sanitary Authorities.

Hospitals.—A Port Nuisance Authority may, with the consent of the Local Government Board, purchase, hire, or erect any building, or purchase land on which to erect a building, within or without its district, for the purpose of a hospital for infected persons. (Sec. 15.)

Easements and Rights.—Subject to the provisions of the Act, the powers of the Lands Clauses Acts may, where the same may be put in force with respect to the taking of land under the Sanitary Acts, be applied to all easements and rights in, over, under, or upon land, whether situated within or without the district of the Sanitary Authority. (Sec. 27.)

Leasing Power—Urban Sanitary Authorities may let temporarily, or for a term, any lands or premises which they can conveniently spare. (Sec. 31.)

Power to Purchase Water-mills, etc.—Any Sanitary Authority may buy up any water-mill, dam, or weir which interferes with the drainage or water supply of its district; and may purchase, within or without its district, any water, or right to take water, without interfering with the navigation of rivers and canals, the water supply of any waterworks, or the rights of individuals. (Secs. 28, 29.)

E.—Provisions relating to Borrowing and Rating.

Borrowing Powers.—*Any* Sanitary Authority may borrow money necessary to defray the expenses incurred by it under the Sanitary Acts, subject to the regulations of those Acts.

An Urban Authority may borrow on the credit of, and may mortgage, any rate out of which it is authorised by the Sanitary Acts to pay sanitary expenses.

A Rural Authority, for the purpose of defraying its *general* expenses, may borrow on the credit of the common fund, and, for the purpose of defraying its *special* expenses, on the credit of any rate out of which such expenses are payable.

The mortgagees or assignees of any mortgage under this Act, may enforce payment of arrears of principal and interest, by the appointment of a receiver. (Sec. 40.)

Any Sanitary Authority or Joint Board possessed of sewage land or plant under the Sewage Utilization Act, 1867, may borrow money for sanitary purposes on the credit of same.

The last-mentioned borrowing power shall be deemed to be distinct from the general borrowing powers of such Authority, or Joint Board, under the Sanitary Acts, where the sums borrowed do not exceed three-fourths of the purchase money of such lands. The interest may be paid out of any rates leviable for sanitary purposes by such Authority or Board. (Sec. 41.)

The Commissioners of Public Works in Ireland may, with the consent of the Treasury, on the recommendation of the Local Government Board, make any loan to any Sanitary Authority for sanitary improvements, in pursuance of any borrowing powers conferred by the Sanitary Acts, whether for works already executed, or yet to be executed; such loan to be repaid within 30 or 50 years, and to bear interest at £3 10s. per cent. per annum, or such other rate as the Treasury may consider necessary to enable the loan to be made without loss to the Exchequer. The loan is to be

made on the security of any fund or rate applicable to sanitary purposes.

In determining the time within which a loan shall be payable, the Commissioners are to take into account the probable duration and continuing utility of the works, for which the same is required.

The Commissioners may reduce the interest, payable on any existing loan, to the rate of £3 10s. per cent. per annum. This section does not extend to any loan obtained under "The Sanitary Loans Act, 1869," for defraying the expenses incurred by the Local Government Board, in performing the duty of a defaulting Sanitary Authority, after the passing of the Act. (Sec. 43.)

Rating Powers.—Any limit imposed on any rate by a Local Act, is not to apply to any rate required to be levied to defray expenses incurred by a Sanitary Authority for sanitary purposes. (Sec. 42.)

The result of this provision is to give to Sanitary Authorities an unlimited power of rating. (See also the Sanitary Act, 1866, secs. 58, 59.)

By the Local Government (Ireland) Act, 1871, sec. 28, Commissioners acting under the Towns Improvement Act, 1854, are empowered to borrow money on the credit of the rates, subject to certain regulations.

The recent Act extends the power conferred by this section to re-borrowing for the purpose of discharging previous loans, and provides that the money so borrowed shall not, with the balances of all the outstanding loans of the Sanitary Authority under the Sanitary Acts, in the whole, at any time exceed twice the net annual value of the premises assessable within the district in respect of which such money may be borrowed, and the period for which the money may be borrowed is extended to sixty years, instead of thirty years. (Sec. 45.)

Water Rate.—In towns in which the Towns Improvement

Act, 1854, is in force, and in which its provisions with respect to water have been adopted, the power of assessment under sec. 60 is increased from one shilling and sixpence to two shillings in the pound. (Sec. 44.)

F.—Amendments of Various Provisions of the Sanitary Acts.

Proceedings by Chief Officer of Police.—The Sanitary Act, 1866, sec. 16, enables the Local Government Board, on proof to their satisfaction that a Nuisance Authority has made default in doing its duty, to direct the chief officer of police, in any place within the jurisdiction of such Authority, to institute any proceeding which such Authority might institute with respect to the removal of nuisances. The section contained no provision for the payment of the expenses of the police officer, and some doubt existed as to the meaning of the term "chief officer of police."

The new Act provides that in the Dublin Police District the term "chief officer" shall mean either of the Commissioners of Police; and elsewhere, the Sub-Inspector of Constabulary of the district, and that such officer may recover from the defaulting Authority all expenses incurred and not paid by the party proceeded against. (Sec. 36.)

Defaulting Sanitary Authorities.—An order of the Local Government Board, under the Sanitary Act, 1866, sec. 49, limiting a time for the performance of its duties by a Sanitary Authority, may be enforced by a writ of mandamus. (Sec. 37.)

Cleansing of Streets, Ashpits, etc.—Every *Urban* Sanitary Authority shall, when the Local Government Board by order so direct, make due provision for the proper cleansing of streets which such Authority is obliged to maintain and repair, the removal of house refuse from premises, and the cleansing of earth closets, privies, ashpits, and cesspools within its district.

If any Sanitary Authority having made such provision fail, without reasonable excuse, after notice in writing from the occupier of any house situated in such district requiring such authority to remove any house refuse, or to cleanse any earth closet, privy, cesspool, or ashpit belonging to such house, or used by the inmates or occupiers thereof, to cause the same to be removed or cleansed, as the case may be, within seven days, the Sanitary Authority shall, on summary conviction be liable to pay to the occupier of such house, a penalty not exceeding five shillings for every day during which such default continues after the expiration of the said period of seven days. (Sec. 39.)

Destruction of Infected Articles.—Every Sanitary Authority shall have power to direct the destruction of any bedding, clothing, or other articles which have been exposed to infection from any dangerous infectious disorder, and to give compensation for the same. (Sec. 50.)

Regulations as to Lodging Houses.—Under the Sanitary Act, 1866, sec. 35, the Local Government Board might, on the application of the Authorities of certain Urban Sanitary Districts, empower such Authorities to make regulations for limiting the number of persons who might occupy a lodging house; and for the registration, inspection, and cleansing of such houses.

The Local Government Board can now declare this enactment to be in force in the district of *any* Sanitary Authority, and their power of making regulations is extended to ventilation, paving and drainage, and the adoption of precautions against contagious diseases. (Sec. 51.)

Notices must be affixed on the outside of common lodging houses and slaughter houses, with the words "registered lodging house," or "slaughter house," on penalty of £5 and 10s. per diem for neglect after conviction. (Sec. 52.)

Polluted Wells and Pumps.—Upon representation to any Sanitary Authority that the water of any well, public or private, or any public pump within its district is injurious to health, such Authority may obtain, from any justices having jurisdiction within such district, an order for the permanent or temporary closing of the well or pump, or for the using of the water for certain purposes only. (Sec. 53.)

Hospital, when deemed to be within District.—For the purposes of the 26th section of the Sanitary Act, 1866, every hospital, or place for the reception of the sick, which shall be declared by an order of the Local Government Board to be situated within a convenient distance of the district of any Sanitary Authority for the purposes of that section, shall be deemed to be within the district of such Sanitary Authority.

Where a justice shall make an order under that section for the removal of a sick person to a hospital or other place, he shall address it to such police or other officer as he shall consider expedient; and every person wilfully disobeying the order, or obstructing the execution of the same, shall be guilty of an offence punishable on summary conviction before two justices, and be liable to a penalty not exceeding £10. (Sec. 54.)

Complaints under Nuisance Removal, etc., Act, 1860.—The right of complaint under sec. 13 of the Nuisance Removal and Diseases Prevention Act, 1860, is extended to nuisances on public premises, and may be exercised by any person aggrieved. (Sec. 55.)

Extension of 26 & 27 Vict., cap. 117, sec. 2, to Milk.—Section 2 of the Nuisance Removal Act for England (Amendment) Act, 1863, which relates to the inspection of articles of food, is extended to milk, and one Justice may convict offenders under that section, and another may order the obnoxious articles to be destroyed. (Sec. 56.)

Warrant to Search for Unsound Food.—Any justice may grant a warrant to a Sanitary Officer to enter premises where there is reason to believe that unsound food is kept or concealed, and to seize same. The statute referred to in the preceding paragraph applied only where the unsound food was openly exposed or kept for sale. (Sec. 57.)

Penalty on False Statements as to Infection in Houses.—Any person letting a house or lodgings, who knowingly makes false answers as to persons suffering from infectious disease having been in such house, is rendered liable to a penalty of £20, or imprisonment for one month, with hard labour. (Sec. 59.)

Quarantine.—Any person neglecting or obstructing the orders made by the Local Government Board, under the Sanitary Act, 1866, sec. 52, with respect to the treatment of persons affected with contagious disease on board ship, shall be liable to a penalty not exceeding £50. (Sec. 60.)

G.—Miscellaneous Provisions.

Transfer of Powers to Local Government Board.—The consent, sanction, or confirmation of the Local Government Board is substituted in each case for that of the Lord Lieutenant, Chief Secretary, or Privy Council, under any local Act, with respect to borrowing money, giving effect to Bye-Laws, or appointment of Sanitary Officers.

The consent of the Board is substituted for that of the Treasury, with regard to borrowing money under the Baths and Wash-houses Act.

The powers of a Secretary of State, under the Markets and Fairs Clauses Act, are transferred to the Board.

The appointment of Analysts shall be subject to the approval of the Board, instead of the Lord Lieutenant.

Provisional Orders.—The Local Government Board

shall not make any provisional order under this Act, unless public notice shall have been previously given by advertisement in two successive weeks in some newspaper published or circulating in the district to which such provisional order relates, and after hearing any objections which may be made thereto by any persons affected thereby, and in cases where the subject matter is one to which a local inquiry is applicable, until it has made, by one of its Inspectors, a local inquiry of which public notice has been given and at which all persons interested have been permitted to attend and make objections.

The Local Government Board may submit to Parliament for confirmation any provisional order made by it in pursuance of this Act, but any such provisional order shall be of no force whatever unless and until it is confirmed by Parliament. If while the Bill confirming such order is pending in either House of Parliament, a petition is presented against any provisional order comprised therein, the Bill, so far as it relates to such order, may be referred to a Select Committee, and the petitioners shall be allowed to appear and oppose it as in the case of a Bill for a special Act.

Any Act confirming any provisional order issued in pursuance of the Sanitary Acts, or any of them, may be repealed or amended by any provisional order made by the Local Government Board and duly confirmed by Parliament. The Local Government Board may revoke, either wholly or partially, any provisional order made by them before the same is confirmed by Parliament; but such revocation shall not be made whilst the Bill confirming the order is pending in either House of Parliament. (Sec. 46.)

Costs of Provisional Orders.—The reasonable costs of any Sanitary Authority in respect of provisional orders made in pursuance of the Sanitary Acts, and of the inquiry preliminary thereto, as sanctioned by the Local Government Board, whether in promoting or opposing the same, shall be

deemed to be expenses properly incurred for sanitary purposes, by the Sanitary Authority interested in or affected by such provisional orders, and such costs shall be paid accordingly; and if thought expedient by the Local Government Board, the Sanitary Authority may contract a loan for the purpose of defraying such costs. (Sec. 47.)

Publication of Orders of the Local Government Board.—Every order of the Local Government Board under the Sanitary Acts (unless otherwise prescribed by the said Acts) shall be published in such manner as that Board may direct. (Sec. 48.)

Powers of Inspectors of Local Government Board.—The Inspectors of the Board may attend meetings of Sanitary Authorities during the transaction of sanitary business, and are entrusted with similar powers, in relation to the Sanitary and Burial Grounds Acts, to those conferred on them under the Poor Law and Medical Charities Acts. (Sec. 11.)

Compensation to Officers.—The Local Government Board may award compensation to any officer of a Sanitary Authority deprived of his office or of any portion of his emoluments by the Act, or by a provisional order made under the Act, and not employed in an office of equal value by such Sanitary Authority. (Sec. 32.)

Notices to Owners and Occupiers.—The governing body of any town, before putting in force any of the powers of the Lands Clauses Acts, with respect to the compulsory taking of land, were required by the Local Government (Ireland) Act, 1871, sec. 4, to publish and serve certain notices in the months of November and December. These notices may now be given in the months of September and October, or October and November. (Sec. 30.)

Transfer of Powers under Alkali Act.—From and after Jan. 1, 1875, the powers of the Board of Trade, under the Alkali Act, 1863, will be transferred to the Local Government Board, if not previously transferred by order of the Lord Lieutenant.

H.—Provisions as to Legal Proceedings.

Legal Position of Sanitary Authority.—Every Sanitary Authority and Joint Board shall, as respects service of notices, legal proceedings, &c., under the Sanitary Acts, stand in the same position as the Authority stood, whose powers, duties, &c., are transferred to such Authority or Board. (Sec. 61.)

Notices.—Notices on behalf of a Sanitary Authority, written or printed, and purporting to be signed by the clerk or acting clerk of such Authority shall be deemed sufficient. (Sec. 62.)

Powers Cumulative.—All powers conferred by this Act are in addition to powers conferred by every other Act, general or local, provisional order, law, or custom. (Sec. 63.)

The Act must, therefore, be construed, as respects each Sanitary District, in connexion with all other Acts, whether general or local, in force in the district, which contain sanitary provisions. A list of general Sanitary Acts will be found at page 31 *seq.*

Penalties.—Penalties under the Act are recoverable in a summary way; in the Dublin Metropolitan Police District, according to the provisions of any Act regulating the duties of justices in such district; in other parts of Ireland before a justice or justices at Petty Sessions, according to the provisions of the Petty Sessions (Ireland) Act, 1851, and any Act amending same.

Penalties recovered by a Sanitary Authority, or their officer, shall be paid to such Authority, and applied in aid of their expenses under the Sanitary Acts. In other cases penalties are to be applied as directed by the Fines Act (Ireland), 1851, and any Act amending same. (Sec. 64.)

Stamp Duty.—Appointments made under the Local Government Board (Ireland) Act, 1872, are exempted from stamp duty. (Sec. 65.)

Payments to Members of Sanitary Authorities.—Any member of a Sanitary Authority or Burial Board who acts as counsel, solicitor, or agent, of such Authority or Board, or accepts, or holds any office under such Authority or Board, or is in any way concerned in any contract made by such Authority or Board, or derives any profit therefrom, *ipso facto* vacates his place as a member of such Authority or Board. (Sec. 38.)

CHAPTER II.

Sanitary Officers.

Public Health Act, 1874, sec. 10—Regulations of Local Government Board—Qualifications, Appointment, Salaries, Tenure of Office, and duties of Sanitary Officers—Orders of Local Government Board (England) with regard to Sanitary Officers.

The provisions of the Public Health Act, 1874, relating to the Officers of Sanitary Authorities are contained in sec. 10, which is as follows:—

"Every Medical Officer of a Dispensary District shall be a Sanitary Officer for such district, or for such part thereof as he shall personally be in charge of, with such additional salary as the Sanitary Authority thereof may determine, with the approval of the Local Government Board; and every Sanitary Authority, whether urban or rural, shall appoint such other Sanitary Officers, including a Medical Superintendent Officer of Health when deemed necessary, as the Local Government Board shall in each case direct, with such salaries or additional salaries as the said Sanitary Authority shall determine, with the approval of the Local Government Board; and the said Board shall assign to the Dispensary Medical Officers, and to the other Sanitary Officers, if any, and to the Medical Superintendent Officer of Health, if such an officer be appointed for the Sanitary District, their respective duties and functions in the discovery or inspection or removal of nuisances, in the supply of pure water, in the making or repairing of sewers and drains, or in generally superintending the execution of the sanitary laws within the district.

"Every such salary or additional salary so determined or approved, shall be payable from such local fund as the Local Government Board shall indicate as properly chargeable therewith, and such part thereof as Parliament shall from time to time determine, shall be recouped to such local fund out of moneys to be voted by Parliament; and the Local Government Board shall have the same powers with regard to the qualification, appointment, duties, regulation of salary, and tenure of office of every Sanitary Officer as they have in the case of the Medical Officer of a Dispensary District: Provided, with regard to salaries or additional salaries, whereof any portion is to be recouped to any local fund from moneys voted by Parliament, the amount of any new salary, and the proportion between any existing salary and the addition thereto, shall be regulated according to a scale to be approved by the Commissioners of Her Majesty's Treasury."

The Local Government Board, in exercise of the power conferred on them by this section, have issued three General Sanitary Orders relating respectively to—

I. *Rural Sanitary Districts* consisting of *entire* Unions.

II. *Rural Sanitary Districts* consisting of *parts of* Unions, of which other parts are Urban Sanitary Districts.

III. *Urban Sanitary Districts.*

These orders "embrace all Urban and Rural Sanitary Authorities in Ireland, except those of Dublin, Belfast, Cork, and Limerick," with the Sanitary Organisation of which the Local Government Board intend to deal separately, "as each possesses an organisation peculiar to itself, and on such a scale as will require much consideration and interchange of views with the Governing Body, in order to adapt it to the provisions of the statute."[1] From a perusal of the section just quoted, and the orders of the Board, it will be seen that every Sanitary Authority, whether Urban or Rural, is *obliged* to maintain the following staff of officers:—

1. *A Consulting Sanitary Officer*, for which office, in Rural Districts, every Medical Officer of the Union, including the Workhouse Medical Officer or Officers, and in Urban Districts every Medical Officer of a Dispensary District, or Workhouse Medical Officer, is eligible, and also, subject to the approval of the Board, any other Medical Practitioner having the same qualifications.
2. *Sanitary Officers* (*ex-officio*) being the Medical Officers of the Dispensary Districts comprised in the District of the Sanitary Authority.
3. *An Executive Sanitary Officer*, for which office, in Rural Districts, the Clerk of the Union, or any Assistant of the Clerk appointed by the Guardians;

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[1] An order relating to Dublin has recently been issued by the Board. Its provisions are for the most part very similar to those of the General Order relating to Urban Districts.

in Urban Districts, the Clerk to the Governing Body, or any Assistant of the Clerk appointed by such Body, shall be eligible.

4. *Sanitary Sub-Officers.*—In Rural Districts, the Relieving Officers of the Union, and the Collectors of Poor Rates are alike eligible for this office. The number of these officers is to be fixed by the Sanitary Authority with the consent of the Board.

The Local Government Board have the same powers with regard to the qualification, appointment, duty, regulation of salary, and tenure of office of every Sanitary Officer, as they have in the case of the Medical Officer of a Dispensary District—*i.e.*, under the Medical Charities Act, 14 & 15 Vict., cap. 68, s. 8.

The Act provides for the appointment of a Medical Superintendent Officer of Health, when deemed necessary, as the Board shall direct. In the orders already issued no reference is made to such an officer.

I. *Qualification.*—By their Orders of September 9, 1874, the Board have directed that the qualifications of a Consulting Sanitary Officer shall be the same as in the case of a Dispensary Medical Officer, viz. :—

1. A medical degree, or diploma, or licence to practise medicine, from some authorised body in Great Britain or Ireland—or the licence of the Apothecaries' Hall, Dublin.
2. A surgical diploma or licence, from some authorised body in Great Britain or Ireland.
3. A certificate from some authorised body that he possesses a competent knowledge of midwifery.

   Under special circumstances the separate medical certificate may be dispensed with by the Board.
4. The minimum of age is 23 years. (See General Order, November 29, 1869.)

No special qualifications are required in the case of the Executive Sanitary Officers, or Sanitary Sub-Officers.

II. *Appointment.*—Every appointment must be made with the approval of the Board.

III. *Regulation of Salary.*—The Board may from time to time, when they see occasion, regulate the amount of salaries, and the time and mode of payment.

The amount of remuneration payable to the different classes of Sanitary Officers is to be determined by each Sanitary Authority, subject to the approval of the Local Government Board.

The salaries so determined are to be paid out of such local fund as the Board shall indicate, and a part thereof, probably one-half, will be recouped to the local fund out of the Imperial Exchequer. The amount of any new salary and the proportion between any existing salary payable to any officer previously to the passing of the Act, and the addition made to it in consideration of the new duties imposed on him by the Act, are to be regulated according to a scale approved of by the Treasury. If this scale be exceeded, the entire amount of the salary or additional salary must be defrayed out of the local fund.

IV. *Tenure of Office.*—The Board may remove any Officer on sufficient grounds, and require the Sanitary Authority to appoint another person in his place. In case the Sanitary Authority fails to appoint a successor within one month, the appointment may be filled up by the Board.

V. *Duties.*—The following have been "assigned" as the Duties of the various Officers, by the Order of September 9, 1874:—

"I. Inspectorial Duties.

"1. Every Sanitary Sub-Officer who shall observe or be informed of any matter demanding, in his opinion, attention from the Sanitary Officer of the Dispensary District in which he has discovered the same, shall notify it forthwith to the Sanitary Officer in writing, specifying the nature of the case in the Form annexed to the Order, and shall preserve a copy thereof in duplicate.

"2. Every Sanitary Officer who shall have been apprised officially or shall otherwise become cognizant of any matter demanding his attention

as aforesaid, shall, as soon as conveniently may be, visit the locality, and if, after due inspection, he finds such matter to involve danger to public health, he shall report thereon to the Sanitary Authority, showing the source from which he received the information, and the date thereof, and the date of his visit of inspection ; he shall also give a sufficient description of the nature of the case, and the remedy which he recommends to be adopted, and shall preserve a duplicate of every such Report.

"II. Executive Duties.

"1. The duty of the Executive Sanitary Officer shall be to attend every meeting of the Sanitary Authority, and to take their directions from time to time on sanitary business, and on the Reports of the Sanitary Officers, and all proceedings arising thereon, and to see that the same are carried out and brought to a conclusion where practicable, in pursuance of the orders of the Authority.

"2. In furtherance whereof we do hereby direct that every Sanitary Officer and Sub-Officer shall, on receiving directions from the Executive Sanitary Officer, attend and assist in all proceedings in which his attendance or assistance may be required.

"3. The duty of the Consulting Sanitary Officer shall be to attend meetings of the Sanitary Authority, whenever required to do so, and to advise them on all matters and proceedings requiring medical knowledge and advice in the administration of the sanitary laws.

"4. *Rural Districts.*—The proceedings of the Board of Guardians acting as the Sanitary Authority shall be recorded in the same manner as the minutes of the proceedings of the Board under the Poor Law and Medical Charities Acts, and a copy of such record shall be annexed to the ordinary minutes of proceedings of the Board of Guardians, and shall be transmitted to the Local Government Board by the Clerk of the Union with such last-mentioned minutes.

"4. *Urban Districts.*—The proceedings of the Governing Body acting as the Sanitary Authority shall be recorded, and a copy thereof shall be transmitted to the Local Government Board by the Clerk to the said Body as soon afterwards as practicable.

"III. Statistics of Disease.

"It shall be the duty of the Consulting Sanitary Officer and of the Sanitary Officers to furnish from time to time to the Local Government Board such statistical returns of sickness and disease, in the case of a Rural Sanitary District, in the workhouse and its hospitals, and in the dispensary districts; and, in the case of an Urban Sanitary District, within such district, as shall from time to time be required from them respectively."

As the directions of the Board with regard to the duties of Officers are somewhat meagre, the following Regulations, issued by the Local Government Board (England), as to the duties of Sanitary Officers appointed under the Public Health Act, 1872 (England), may be found useful by Sanitary Authorities in framing rules for the guidance of their officers.

"I. Medical Officers.

"The following shall be the duties of a Medical Officer of Health in respect of the Sanitary District for which he is appointed ; or if he shall be appointed for more than one district, or for a part of a district, then in respect of each such districts, or of such part :—

"1. He shall inform himself as far as practicable respecting all influences affecting or threatening to affect injuriously, the public health within the district.

"2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

"3. He shall by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

"4. He shall be prepared to advise the Sanitary Authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the Sanitary Authority ; and in cases requiring it, he shall certify, for the guidance of the Sanitary Authority, or of the justices, as to any matter in respect of which the certificate of a Medical Officer of Health or a medical practitioner is required as the basis, or in aid of sanitary action.

"5. He shall advise the Sanitary Authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make.

"6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay, and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, assist in the execution of the same.

"7. On receiving information from the Inspector of Nuisances that his intervention is required in consequence of the existence of any

nuisance injurious to health or of any overcrowding in a house, he shall, as early as practicable, take such steps authorised by the statutes in that behalf, as the circumstances of the case may justify and require.

"8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the Sanitary Authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, exposed for sale, or deposited for the purpose of sale or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he finds that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be seized, taken, and carried away, in order to be dealt with by a justice according to the provisions of the statutes applicable to the case.

"9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the Sanitary Authority, duly confirmed, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

"10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

"11. He shall attend at the office of the Sanitary Authority, or at some other appointed place, at such stated times as they may direct.

"12. He shall from time to time report, in writing, to the Sanitary Authority his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

"13. He shall keep a book or books, to be provided by the Sanitary Authority, in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon, and of any action taken on previous reports, and shall produce such book or books, whenever required, to the Sanitary Authority.

"14. He shall also prepare an Annual Report, to be made to the end of December in each year, comprising tabular statements of the sickness and mortality within the district, classified according to diseases, ages, and localities, and a summary of the action taken during the year for preventing the spread of disease. The Report shall also contain an account of the proceedings in which he has taken part or advised under the Sanitary Acts, so far as such proceedings relate to conditions

dangerous or injurious to health, and also an account of the supervision exercised by him, or on his advice, for sanitary purposes over places and houses that the Sanitary Authority has power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, bakehouses, and workshops.

"15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the Board, on forms to be provided by them, a quarterly return of the sickness and deaths within the district, and also a copy of each annual and of any special Report.

"16. In matters not specifically provided for in this order, he shall observe and execute, so far as the circumstances of the district may require, the instructions of the Local Government Board on the duties of Medical Officers of Health, and all the lawful orders and directions of the Sanitary Authority applicable to his office.

"17. Whenever the Diseases Prevention Act of 1855 is in force within the district, he shall observe the directions and regulations issued under that Act by the Local Government Board, so far as the same relate to or concern his office.

"18. Where more than one Medical Officer of Health shall be appointed by a Sanitary Authority, such authority, with the approval of the Local Government Board, may either assign to each of the officers a portion of the district, or may distribute the duties of Medical Officer of Health amongst such officers."

"II. INSPECTOR OF NUISANCES—i.e., *Sanitary Sub-Officer.*

"The following shall be the duties of an Inspector of Nuisances in respect of the Sanitary District for which he is appointed, or if he shall be appointed for more than one district, or for a part of a district, then in respect of each of such districts, or of such part :—

"1. He shall perform, either under the special directions of the Sanitary Authority or (so far as authorised by the Sanitary Authority) under the directions of the Medical Officer of Health, or in cases where no such directions are required, without such directions, all the duties specially imposed on an Inspector of Nuisances by the Sanitary Acts, so far as the same are in force in the district, or by the orders of the Local Government Board.

"2. He shall attend all meetings of the Sanitary Authority when so required.

"3. He shall by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself

informed in respect of the nuisances existing therein that require abatement under the Sanitary Acts.

"4. On receiving notice of the existence of any nuisance within the district, or of the breach of any byelaws or regulations made by the Sanitary Authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of byelaws or regulations.

"5. He shall report to the Sanitary Authority any noxious or offensive businesses, trades, or manufactories established within the district, and the breach or non-observance of any byelaws or regulations made in respect of the same.

"6. He shall report to the Sanitary Authority any damage done to any works of water supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

"7. He shall, from time to time, and forthwith, upon complaint, visit and inspect the shops and places kept or used for the sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, or flour, or as a slaughter-house, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, which may be therein; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized, and take such other proceedings as may be necessary in order to have the same dealt with by a Justice: Provided, that in any case of doubt arising under this clause, he shall report the matter to the Medical Officer of Health, with the view of obtaining his advice thereon.

"8. He shall, when and as directed by the Sanitary Authority, procure and submit samples of food or drink, and drugs suspected to be adulterated, to be analysed by the analyst appointed under the Adulteration of Food Act, 1872, and upon receiving a certificate stating that the articles of food or drink, or drugs, are adulterated, cause a complaint to be made, and take the other proceedings prescribed by that Act.

"9. He shall give immediate notice to the Medical Officer of Health of the occurrence within his district of any contagious, infectious, or epidemic disease of a dangerous character; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any over-crowding in a house, he shall forthwith inform the Medical Officer thereof.

"10. He shall, subject in all respects to the directions of the Sanitary Authority, attend to the instructions of the Medical Officer of Health with respect to any measures which can be lawfully taken by him under the Sanitary Acts for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

"11. He shall enter from day to day, in a book to be provided by the Sanitary Authority, particulars of his inspections and of the action taken by him in the execution of his duties. He shall also keep a book or books, to be provided by the Sanitary Authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the Sanitary Acts, and shall keep any other systematic records that the Sanitary Authority may require.

"12. He shall at all reasonable times when applied to by the Medical Officer of Health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of Inspector of Nuisances relate.

"13. He shall, if directed by the Sanitary Authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

"14. In matters not specifically provided for in this order, he shall observe and execute all the lawful orders and directions of the Sanitary Authority, and the orders which the Local Government Board may hereafter issue, applicable to his office.

"15. Where more than one Inspector of Nuisances shall be appointed by a Sanitary Authority, such Authority, with the approval of the Local Goverment Board, may either assign to each of the Inspectors a portion of the district, or may distribute the duties of Inspector of Nuisances amongst such Inspectors."

CHAPTER III.

List of Statutes Relating to Public Health in Ireland.

Class I.—General Sanitary Acts (*arranged in Chronological Order*).

Class II.—Miscellaneous Acts (*the Subjects arranged in Alphabetical Order—the Statutes relating to each Subject in Chronological Order*).

CLASS I.

General Sanitary Acts.

[*Arranged in chronological order.*]

Note.—The Roman numerals in the last column, and foot-notes, refer to the Reference Nos., column 1.

Reference No.	Title of Act	Statute	Portions of Acts which apply to Ireland	Acts by which extended to Ireland
I.	"The Public Health Act, 1848," (*a*)	11 & 12 Vic. cap. 63,	Secs. 45, 46,	viii. sec. 4.
			51, 54,	xii. sec. 4 ; xvii. sec. 23.
			67,	x. sec. 42.
			75-80,	x. sec. 56.
			90, 91, 92, 98,	iv. sec. 58; xii. sec. 6; xvii. sec. 23.
			111, 112,	iv. sec. 59 ; viii. sec. 6.
			120,	xii. sec. 6 ; xvii. sec. 23.
			123-128,	viii. sec. 8 ; x. sec. 9.
			139, 140,	iii. sec. 42 ; x. sec. 57, 14.
			143,	viii. sec. 5.
			144,	iv. sec. 30 ; viii. sec. 4.
			146,	xii. sec. 6 ; xvii. sec. 23.
			150 (part of)	vi. sec. 5 ; viii. sec. 4.
			Schedule C.,	iv. sec. 59 ; viii. sec. 6.
II.	"Diseases Prevention Act, 1855," (*b*)	18 & 19 Vic. cap. 116,	All, except secs. 2 & 3,	x. sec. 62.
III.	"The Nuisances Removal Act for England, 1855," (*c*)	18 & 19 Vic. cap. 121,	All, except secs. 1, 3, 4, 6, 7, 9, 26, 38,	x. secs. 57, 14.
IV.	"The Local Government Act, 1858," (*d*)	21 & 22 Vic. cap. 98,	Secs. 30,	viii. sec. 4.
			32 (part of)	xii. sec. 5 ; xvii. sec. 23.
			33,	xii. sec. 4; xvii. sec. 23.
			51–53,	x. sec. 56.
			54,	xii. sec. 6 ; xvii. sec. 23.

			57–59,	viii. sec. 6.
			58, 59,	xii. sec. 6; xvii. sec. 23.
			62, 63, 65,	xii. sec. 6; xvii. sec. 23.
			68–74,	viii. sec. 4.
			75,	viii. sec. 7.
			78, Form B.	viii. sec. 6.
V.	The Nuisances Removal and Diseases Prevention (Amendment) Act, 1860," (*e*)	23 & 24 Vic. cap. 77,	All, except secs. 2, 3, 4, 6, & 11 (part of)	x. secs. 57, 14.
VI.	"The Local Government Act, 1858, Amendment Act, 1861,"	24 & 25 Vic. cap. 61,	Secs. 4–6,	viii. sec. 4.
			19,	viii. sec. 6.
			20,	x. sec. 56.
			23,	xii. sec. 6; xvii. sec. 23.
VII.	"The Nuisances Removal Act for England, (Amendment) Act 1863," (*i*)	26 & 27 Vic. cap. 117,	All,	xv. sec. 1; x. secs. 57, 14.
VIII.	"The Sewage Utilization Act, 1865," (*f*)	28 & 29 Vic. cap. 75,	All, omitting schedule, & sec. 2 (part of)	Passed for Great Britain and Ireland.
IX.	"The Nuisances Removal Act, (No. 1) 1866,"	29 & 30 Vic. cap. 41,	Sec. 2,	Ditto.
X.	"The Sanitary Act, 1866," (*g*)	29 & 30 Vic. cap. 90,	All, except secs. 5, 6, 7, 17, 33, 43, 44, 60, and schedule 1.	Passed for England and Ireland.
XI.	"The Sewage Utilization Act, 1867,"	30 & 31 Vic. cap. 113,	All,	Passed for Great Britain and Ireland.
XII.	"The Sanitary Act, 1868,"	31 & 32 Vic. cap. 115,	All, except secs. 2 & 9,	xvii. sec. 23.
XIII.	"The Artizans' and Labourers' Dwellings Act, 1868,"	31 & 32 Vic. cap. 130,	—	Passed for Great Britain and Ireland.
XIV.	"The Sanitary Loans Act, 1869,"	32 & 33 Vic. cap. 100,	All, except sec. 2,	xvii. sec. 23.

General Sanitary Acts.—*Continued.*

Reference No.	Title of Act	Statute	Portions of Acts which apply to Ireland	Acts by which extended to Ireland
XV.	The Sanitary Act, 1866, Amendment (Ireland) Act (1869),	32 & 33 Vic. cap. 108,	All,	Passed for Ireland.
XVI.	"The Sanitary Act, 1870,"	33 & 34 Vic. cap. 53,	Sec. 4.	This Act was passed for the United Kingdom, but its provisions are inapplicable to Ireland, with the exception of sec. 4.
XVII.	"The Local Government (Ireland) Act, 1871," (*h*)	34 & 35 Vic. cap. 109,	All, except secs. 6, 9, 16, 28 (par. 3), 31,	Passed for Ireland.
XVIII.	"The Local Government Board (Ireland) Act, 1872," (*i*)	35 & 36 Vic., cap. 69,	All, except sec. 8,	Ditto.
XIX.	"The Sanitary Act, 1866, Ireland, Amendment Act, 1873,"	36 & 37 Vic. cap. 78,	All,	Ditto.
XX.	"The Public Health (Ireland) Act, 1874,"	37 & 38 Vic. cap. 93,	All,	Ditto.

(*a.*) As amended by iv. and vi.
(*b.*) As amended and modified by v. and x.
(*c.*) As amended by x.
(*d.*) As amended by vi.
(*e.*) As amended by x.
(*f.*) As amended by x. and xi.
(*g.*) As amended by xii., xiv., xv., xvi., xvii., xviii., xix., xx.
(*h.*) As amended by xviii. and xx.
(*i.*) As amended by xx.

CLASS II.

Miscellaneous Acts.

[*The Subjects are arranged in alphabetical order. The Statutes relating to each subject in chronological order.*]

ADULTERATION—See "Food."

ALKALI MANUFACTORIES.

"The Alkali Act, 1863,"	26 & 27 Vic. cap. 124.
An Act to make perpetual the Alkali Act, 1863,	31 & 32 Vic. cap. 36.
"The Alkali Act, 1874,"[1]	37 & 38 Vic. cap. 43.

BAKEHOUSES.

"The Bakehouse Regulation Act, 1863,"	26 & 27 Vic. cap. 40.

BATHS AND WASH-HOUSES.

An Act for promoting the voluntary establishment in boroughs and certain towns in Ireland of public Baths and Wash-houses,	9 & 10 Vic. cap. 87.

BURIAL OF POOR PERSONS.

An Act to enable Boards of Guardians in Ireland to provide coffins and shrouds for the burial of poor persons, who at the time of their death were not in receipt of relief from the Poor Rates,	29 Vic. cap. 38.

BURIAL-GROUNDS ACTS.

"The Burial Grounds (Ireland) Act, 1856,"	19 & 20 Vic. cap. 98.
An Act to amend the Burial Grounds (Ireland) Act, 1856,	23 & 24 Vic. cap. 76.
An Act to amend the law which regulates the burial of persons in Ireland not belonging to the Established Church,	31 & 32 Vic. cap. 103.
"The Irish Church Act, 1869" (part of),	32 & 33 Vic. cap. 42, sec. 26.

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[1] Not to come into operation until March 1, 1875.

CLAUSES ACTS.

"Markets and Fairs Clauses Act, 1847,"	10 Vic. cap. 14.
"Gas Works Clauses Act, 1847,"	10 Vic. cap. 15.
"Commissioners' Clauses Act, 1847,"	10 Vic. cap. 16.
"Waterworks Clauses Act, 1847,"	10 Vic. cap. 17.
"Towns Improvement Clauses Act, 1847,"	10 & 11 Vic. cap. 34.
"Waterworks Clauses Act, 1863,"	26 & 27 Vic. cap. 93.
"Gas and Waterworks Facilities Act, 1870,"	33 & 34 Vic. cap. 70.
"Gas Works Clauses Act, 1871,"	34 & 35 Vic. cap. 41.
"Gas and Waterworks Facilities Act, 1870, Amendment Act, 1873,"	36 & 37 Vic. cap. 89.

See also Lands Clauses Acts.

COMMON LODGING HOUSES.

"The Common Lodging Houses Act, 1851,"	14 & 15 Vic. cap. 28.
"The Common Lodging Houses Act, 1853,"	16 & 17 Vic. cap. 41.
"The Common Lodging Houses Act, Ireland, 1860,"	23 Vic. cap. 26.

FACTORIES AND WORKSHOPS
(Regulation of).

"The Factory Act, 1833,"	3 & 4 Wm. IV. cap. 103.
"The Factory Act, 1844,"	7 & 8 Vic. cap. 15.
"The Factory Act, 1856,"	19 & 20 Vic. cap. 38.
"The Factory Acts Extension Act, 1864,"	27 & 28 Vic. cap. 48.
"The Factory Acts Extension Act, 1867,"	30 & 31 Vic. cap. 103.
"The Workshop Regulation Act, 1867,"	30 & 31 Vic. cap. 146.
"The Factory and Workshop Act, 1870,"	33 & 34 Vic. cap. 62.
"The Factory and Workshop (Jews) Act, 1871,"	34 Vic. cap. 19.
"The Factory and Workshop Act, 1871,"	34 & 35 Vic. cap. 104.
"The Factory Act, 1874,"	37 & 38 Vic. cap. 44.

FOOD, &c. (Adulteration of).

An Act for preventing the Adulteration of articles of Food or Drink,	23 & 24 Vic. cap. 84.
An Act to regulate the sale of Poisons in Ireland,	33 & 34 Vic. cap. 26.
An Act to amend the law for the prevention of Adulteration of Food, Drink, and Drugs,	35 & 36 Vic. cap. 74.

LABOURING CLASSES DWELLINGS.

"The Labouring Classes Lodging Houses and Dwellings Act (Ireland), 1866,"	29 & 30 Vic. cap. 44.
"The Labouring Classes Dwelling Houses Act, 1867,"	30 & 31 Vic. cap. 28.
"The Artizans' and Labourers' Dwellings Act, 1868,"	31 & 32 Vic. cap. 130.

LANDS CLAUSES ACTS.

"The Lands Clauses Consolidation Act, 1845,"	8 Vic. cap. 18.
"The Railways Act (Ireland) 1851,"	14 & 15 Vic. cap. 70.
"The Railways Act (Ireland) 1860,"	23 & 24 Vic. cap. 97.
"The Lands Clauses Consolidation Acts Amendment Act, 1860,"	23 & 24 Vic. cap. 106.
"The Railways Act (Ireland) 1864,"	27 & 28 Vic. cap. 71.
"The Railway Traverse Act,"	31 & 32 Vic. cap. 70.

MEDICAL CHARITIES.

An Act to provide for the better distribution, support, and management of Medical Charities in Ireland,	14 & 15 Vic. cap. 68.
An Act to extend the powers of Poor Law Inspectors and Medical Inspectors in Ireland,	31 & 32 Vic. cap. 74.
An Act to provide for Superannuation Allowances to Medical Officers of Poor Law Unions, and of Dispensary Districts in Ireland,	32 & 33 Vic. cap. 50.

POOR LAW ACTS

(As defined by the Public Health (Ireland) Act, 1874).

1 & 2 Vic. cap. 56.	14 & 15 Vic. cap 68.
2 Vic. cap. 1.	19 Vic. cap. 14.
6 & 7 Vic. cap. 92.	25 & 26 Vic. cap. 83.
10 Vic. cap. 31.	26 Vic. cap. 21.
10 & 11 Vic. caps. 84, 90.	28 Vic. cap. 26.
11 & 12 Vic. caps. 25, 47.	29 Vic. cap. 38.
12 & 13 Vic. caps. 4, 104.	32 & 33 Vic. caps. 25, 54.

PUBLIC PLEASURE GROUNDS.

"Recreations Grounds Act, 1859,"	22 Vic. cap. 27.
"The Public Parks (Ireland) Act, 1869,"	32 & 33 Vic. cap. 28.
"The Public Parks (Ireland) Act, 1869, Amendment Act 1872,"	35 Vic. cap. 6.

REGISTRATION OF BIRTHS AND DEATHS.

"The Registration of Births and Deaths (Ireland) Act,"	26 Vic. cap. 11.

STEAM WHISTLES.

An Act to regulate the use of Steam Whistles in certain manufactories,	35 & 36 Vic. cap. 61.

TOWNS IN IRELAND

(Acts relating to the Government of).

An Act to make provision for the lighting, cleansing, and watching of cities and towns corporate and market towns in Ireland in certain cases,	9 Geo. IV. cap. 82.
An Act for the regulation of Municipal Corporations in Ireland,	3 & 4 Vic. cap. 108.
"The Towns Improvement (Ireland) Act, 1854,"	17 & 18 Vic. cap. 103.
"The Local Government (Ireland) Act, 1871,"	34 & 35 Vic. cap. 109.

VACCINATION.

An Act to make further provision for the practice of Vaccination in Ireland,	21 & 22 Vic. cap. 64.
An Act to further extend and make compulsory the practice of Vaccination in Ireland,	26 & 27 Vic. cap. 52.
An Act to amend the Act 26 & 27 Vic. cap. 52,	31 & 32 Vic. cap. 87.
"The Public Health (Ireland) Act, 1874," section 58,	37 & 38 Vic. cap. 93.

CHAPTER IV.

Index to the Sanitary Acts comprised in List of Statutes—Class I., pp. 32–34.

[*The Roman Numerals refer to the "Reference Numbers," column* 1, *pages* 32–34].

ABBREVIATIONS.

S. A., Sanitary Authority.	U. S. D., Urban Sanitary District.
R. S. A., Rural Sanitary Authority.	L. G. B., Local Government Board for Ireland.
U. S. A., Urban " "	N. R., Nuisance Removal.
S. D., Sanitary District.	P. O., Provisional Order.
R. S. D., Rural Sanitary District.	

LOCAL GOVERNMENT BOARD (IRELAND)—*continued.*

1. of Poor Law Commissioners, xviii. ss. 2–5.
2. of Lord Lieut., Privy Council, and Chief Secretary, xviii. ss. 2–5.

to make annual report to Lord Lieutenant, xviii. s. 7.

Powers of under Public Health (I.) Act, 1874.

1. may divide Electoral Division of R. S. D. into wards, xx. s. 4.
2. may by P. O. alter sanitary districts, xx. s. 5.
3. may determine what are sanitary matters, within meaning of sections 7 & 32; xx. ss. 7, 32.
4. shall indicate from what fund salaries of officers of S. A. shall be paid, xx. s. 10.
5. shall direct appointment of officers of S. A. and assign their duties, xx. s. 10.
6. with regard to appointment, duties, salary, tenure of office, &c., of officers, xx. s. 10.
7. may by P. O. alter incidence of charge, xx. s. 12.
8. may determine what are special expenses, xx. s. 13.
9. may by P. O. decide as to apportionment of expenses, xx. s. 13.
10. may determine on what area expenses shall be chargeable, xx. s. 13.
11. shall make order as to appropriation of special poundage rate, xx. s. 14.
12. may direct inquiry under Burial Grounds Acts, xx. s. 18.
13. may form United San. District, xx. s. 19.
14. may give directions as to publication of P. O. for forming united district, xx. s. 20.
15. shall by P. O. determine constitution, and define powers, &c., of Joint Board, xx. ss. 21, 22.
16. may by P. O. repeal or amend Local Acts, and alter area to which they apply, xx. s. 26.
17. may award compensation to officers of S. A. in certain cases, xx. s. 32.
18. may by order, on application of S. A., settle differences as to transfer of powers or property, xx. s. 35.
19. may direct S. A. to make provision for cleansing streets, ashpits, &c., and removing refuse, xx. s. 39.
20. may recommend Pub. Works Commissioners to lend money to S. A., xx. s. 43.
21. may submit P. O. to Parliament, xx. s. 46.

CHAPTER V.

Vital Statistics—Science of Statistics.

Meaning of the term Vital Statistics.—Principle on which Vital Statistics are based.—Their Uses.—Method of framing Statistics.—Calculation of Percentages.—Means.—Arithmetical Mean or Average.—Calculation of Means and Averages.—Method by Successive Means.—Determination of Annual and Percentage Ratios from Quarterly and Weekly Registrations.—Comparison of Statistics relating to various periods in the same place.—Comparison of Statistics in different places.—Diagrammatic representation of Statistical Data.—Registration of Disease.—Law of the duration of Sickness.

Vital Statistics may be defined as that branch of Statistical Science which has for its object the discovery of the laws which govern the physical condition of mankind—an object to be attained by the elucidation of the different problems connected with the beginning, progress, and end of the *life* of man—in this case regarded, not as an individual, but as a species. The manner of his birth and death is investigated, and, in a still more extended sense, the term includes the consideration of all that relates to the development of man—his height, weight, and strength, the influence of external circumstances upon him, etc., at various periods of his life. The subject-matter of vital statistics, like that of statistics in general, consists in a number of isolated facts, or numerical units (the term used by Dr. Parkes), all of the same nature, and comparable with one another, so as to admit of their addition and classification.

The meaning attached to the word "Man" in this definition should be remembered, for it is only by a correct appreciation of its significance that we shall be able to comprehend the great principle which underlies the science

of vital statistics. General laws are to be discovered by the study of phenomena extending over a large number of instances, and in the same way, by studying man in the abstract, we arrive at results which have all the force and all the characters of general laws. In the words of the illustrious M. Quetelet, "We must, before all, lose sight of man taken by himself, and consider him only as a fraction of the species. In stripping him of his individuality, we shall eliminate all that is merely accidental; and the individual peculiarities which exercise little or no effect on the mass will be effaced of themselves and permit us to lay hold on general results."[1]

In consequence of this generalisation in the laws which relate to man, these laws cease to be applicable in individual cases, and are true only for society at large. As Dr. Russell Reynolds, speaking of statistics in his "Address in Medicine," at the Norwich meeting of the British Medical Association,[2] says:—"Life is too complex in each individual for the application of many general laws; and, least of all, for the deductive use of those which are derived from a mere regard to numbers."

An example or two will serve to illustrate this principle of generalisation in statistical inquiries. The length of a single life cannot be guessed at, much less depended on. Yet by a consideration of a great number of lives, we obtain a constant quantity—the *expectation of life*—which is so near the truth as to enable us to found a system of life annuities and of life insurance, and by doing this to confer an inestimable boon on thousands of our fellow-creatures. Or to give another instance:—acts, which are purely voluntary, and most inconstant as regards individual men, are found to be subject to fixed and discoverable laws when referred to nations or communities. Thus M. Quetelet, having shown by a table the remarkable constancy, as regards number, with which murders are committed in France year by year, observes:—"A tribute which man pays with more regularity than that which he owes to nature or to the treasury of the State, is the one he pays to crime. Unhappy condition of the human species! We can tell before-

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[1] *Physique Sociale, ou Essai sur le Développement des Facultés de l'Homme.* Par Ad. Quetelet. Tome i. P. 95. Bruxelles: 1869.
[2] *Brit. Med. Journ.* Aug. 15, 1874. P. 204.

hand how many individuals will stain their hands with the blood of their fellows, how many will turn out forgers or poisoners, much as we can predicate the births and the deaths which should succeed each other."[1]

The uses of vital statistics are exceedingly numerous. In the first place they afford most valuable information as to the health of a people and the conditions which influence it for good or evil. The investigation of these conditions has already been attended with such success as to have resulted to some extent in the diminution of sickness, and the extension of the *mean* life of man. The application of vital statistics in life insurance is another illustration of their utility. By their aid we study the birth-rate, marriage-rate, and death-rate of a population; the relative number of still-births, the amount of sickness in a population, the mortality of different diseases at different periods, and in different places; the mean age at death of a population, the mean duration of life (*vie moyenne*), the probable duration of life (*vie probable*), the expectation of life, or, as Dr. William Farr has termed it, the mean after-lifetime; the influence of occupations, ages, locality, etc., on health; the death-rates in various classes of the population, and many similar subjects of inquiry.

In the compilation of statistics the first step is to arrange in groups certain isolated facts, or numerical units, according as they differ from the remainder of the facts under consideration by some leading distinctive feature. For example: the patients in the wards of a hospital represent a number of units comparable with each other in consequence of the characteristic common to such patients of being sick. The statistician then proceeds to classify these patients, or numerical units, let us say according to the diseases from which they suffer—fever, pneumonia, bronchitis, measles, and so on; or according to their age, or sex, or any other distinguishing *sub*-characteristic. As regards such a classification, Dr.

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[1] *Loc. cit.* P. 97.

Parkes[1] admirably observes :—“ An accurate diagnosis of the disease is essential, or statistical analysis can only produce error. If the numerical units are not precise and comparable, it is better not to use them. A great responsibility rests on those who send in inaccurate statistical tables of diseases; for it must be remembered that the statist does not attempt to determine if his units are correct; he simply accepts them, and it is only if the results he brings out are different from prior results that he begins to suspect inaccuracy.”

The classification having been made, the groups have next to be compared with the total number of units taken collectively, and also with each other. To discover the relation subsisting between these groups we have recourse to an arithmetical proportion which gives us a constant numerical standard in percentages, or multiples of a percentage.

An example will make the explanation of the process very simple. The total number of deaths registered in Dublin during 1873 amounted to 8,212. Of these 1,378 were caused by zymotic affections, 1,665 by constitutional diseases, 3,646 by local diseases, 1,091 by developmental diseases, 224 were violent deaths, and in 208 cases the cause of death was not specified or was ill-defined. Now, here each individual death is a numerical unit. Several of these units have been grouped together by the Registrar-General, according as they possess some distinguishing feature in common, under the headings zymotic, constitutional, local, developmental, violent, and unspecified deaths. Thus the first process in the statistical consideration of the deaths in Dublin during 1873 is accomplished. But it is further required to ascertain the proportion which the deaths in the various classes or groups named bore to the deaths from all causes. Choosing 100 as a constant standard to which we can refer all these groups, as well as the collective number of deaths, 8,212, which they go to make up, we have the following proportions:—

8212 : 100 : : 1378 : 16·8 =	the percentage	of	zymotic	deaths.
8212 : 100 : : 1665 : 20·3 =	,,	,,	constitutional	,,
8212 : 100 : : 3646 : 44·4 =	,,	,,	local	,,
8212 : 100 : : 1091 : 13·3 =	,,	,,	developmental	,,
8212 : 100 : : 224 : 2·7 =	,,	,,	violent	,,
8212 : 100 : : 208 : 2·5 =	,,	,,	deaths from unspecified causes.	

[1] *A Manual of Practical Hygiene.* Fourth Edition. 1873. P. 484.

The above is a full statement of a series of simple proportions, but a consideration of the statement in each case will show that, if n represent the smaller and N the larger of the given quantities or numbers, the simple formula $\frac{n \times 100}{N} = x$, the number per cent. sought for in any simple proportion. Of course in these proportions, or fractions, any multiple of 100 can take its place. For instance, we could say

$$8212 : 1000 :: 1378 : 168$$

instead of

$$8212 : 100 :: 1378 : 16 \cdot 8.$$

Or generally, adopting the formula given above,

$$\frac{n \times 1000}{N} = 10x, \text{ and } \frac{n \times 10,000}{N} = 100x.$$

This is sometimes convenient, especially in the case of very small results, for decimal places are thus avoided.

When we have collected several similar groups of facts or observations, and desire to draw conclusions from them as to their probable recurrence at some future time, it becomes necessary to ascertain their *Mean.* This may be effected in various ways, but the simplest method is by dividing the sum of the facts or observations by the number of them. We thus find their *Arithmetical Mean* or *Average.* The relation of this mean to the series of numbers which yield it is such that the numbers which are greater than the mean added together are exactly equal to the sum of the numbers which are less than the mean. If we regard the first set as positive and the second as negative, we at once see that the sum of the differences of the numbers of a series from their arithmetical mean (or the sum of their errors) is always equal to zero.

Take an example :—The arithmetical mean of the series 1, 4, 5, 8, 10, 2, is 5. In this series, 8 and 10 are greater than 5, the sum of their excess being $+8$; while 1, 4, and 2 are less than 5, the sum of their deficiency being -8. Then $8-8=0$, the sum of the errors (or differences from the arithmetical mean) of the series. Now, suppose we want to obtain the arithmetical mean or average of the annual death-rate per 1,000 for Dublin in the ten years ending 1873, we add together the death-rates for each individual year of the series, and divide the result or sum by 10, the number of years under consideration.

$$23+26+29+27+25+24+25+26+29+26=260$$

Then, $\frac{260}{10}=26 \cdot 0=$ the average death-rate for the ten years.

Are we now justified in assuming that the average death-rate for Dublin in the *next* ten years will be 26 per 1,000 also? By no means; for, apart from all other considerations, arithmetical means or averages are reliable in cases of this kind only when they deal with extremely lengthened periods; in other words, only when the number of facts or units is very considerable. This is well shown even in the illustration we have given. The death-rate for 1864 was 23; for 1865 it was 26. The average of these figures is 24·5. But the average death-rate of the two years following, 1866 and 1867, rose to 28. Hence we cannot draw accurate conclusions as to the future from a small series of numerical units. The greater the number of units, the more nearly will their average approach the truth. The amount of departure from the average within which, on one side or the other, it is an even chance that the truth exists, is called the *probable error* of the arithmetical mean. This is to be found by Poisson's rule, which is based on the "Theory of Probabilities." Dr. Parkes[1] states this valuable rule as follows:—

Let μ be the total number of cases recorded.
m be the number in one group.
n be the number in the other.
So that $m+n=\mu$.

The proportion of each group to the whole will be respectively $\frac{m}{\mu}$ and $\frac{n}{\mu}$, but these proportions will vary within certain limits in succeeding instances. The extent of variation will be within the proportions represented by

$$\frac{m}{\mu}+2\sqrt{\frac{2 \cdot m \cdot n}{\mu^3}}$$

and

$$\frac{m}{\mu}-2\sqrt{\frac{2 \cdot m \cdot n}{\mu^3}}$$

[1] *Loc. cit.* P. 485.

It will be obvious that the larger the value of μ the less will be the value of $\sqrt{\frac{2 \cdot m \cdot n}{\mu^3}}$, and consequently the less will be the limits of error in the simple proportion $\frac{m}{\mu}$.

An example will show how this rule is worked. The following is given by Gavarret (*Statistique Médicale*, 1840, p. 284) :—

Louis, in his work on Typhoid Fever, endeavours to determine the effect of remedies, and gives 140 cases, with 52 deaths and 88 recoveries. What is the mortality per cent., and how near is it to the true proportion?

$$m = 52 = \text{number of deaths.}$$
$$n = 88 = \text{number of recoveries.}$$

$$\mu = 140 = \text{total number of cases,}$$

i.e., 37 deaths in 100 cases, or more precisely 37,143 deaths in 100,000 cases. How near is this ratio to the truth? The possible error is as follows—the second half of the formula, viz. :—

$$2\sqrt{\frac{2 \cdot m \cdot n}{\mu^3}}$$

will be

$$2\sqrt{\frac{2 \times 52 \times 88}{(140)^3}} = 0\cdot11550 \text{ to unity.}$$

(Or 11,550 in 100,000.)

The mortality being 37·143 per cent., or 37,143 deaths in 100,000 cases, in these cases, it may be in other 140 cases either

$$37{,}143 + 11{,}550 = 48\cdot693 \text{ per cent.,}$$

or

$$37{,}143 - 11{,}550 = 25\cdot593 \quad ,,$$

In other words, in successive 140 cases the mortality will range from 49 per cent. (nearly) to 26 per cent. (nearly), so that Louis' numbers are far too few to give even an approximation to the true mean.

With a view of obtaining a close approximation to the truth in calculations made with a moderate number of units, an adaptation of the method of arithmetical means may be used. This is what Professor Radicke[1] has denominated the "Method of Successive Means." If we take the death-rate in Dublin for the years 1864–73 inclusive, already

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[1] *New Syd. Soc.* Vol. xi. 1861. "On the Importance and Value of Arithmetic Means." P. 197 *seq.*

given, the successive means will be $\frac{23+26}{2}$, $\frac{23+26+29}{3}$, $\frac{23+26+29+27}{4}$, $\frac{23+26+29+27+25}{5}$, and so on. It will be found that after a few calculations the results will, in all cases, begin to closely approximate each other. In the example given, the results to three decimal places are—

24·500	26·000	25·625
26·000	25·667	26·000
26·250	25·571	26·000

In this series the first result alone shows a considerable discrepancy from all the others, so that we conclude that the number of numerical units included in it is too small to admit of conclusions being drawn from them. The degree of uncertainty in the whole series may fairly be represented by the arithmetical mean error, or the sum of the variations from the arithmetical mean divided by the number of means. As we have already seen that the sum of the differences of the numbers of a series from their arithmetical mean always $=0$, from the plus and minus signs neutralising each other, it is clear that all the variations or errors together must in this case be taken as positive; but Radicke points out that it is preferable to employ the *Quadratic Mean*, which is equivalent to the *square root of the Arithmetical Mean of the squares of the given numbers*. It should be remembered that an average is never applicable in a particular case, and that the lowest and highest values in any series of units should be noted as well as the average. On this latter point Dr. Parkes[1] quotes Dr. Guy's remark—in an article on "Statistics," in the *Cyclopædia of Anatomy and Physiology*—"Averages are numerical expressions of probabilities; extreme values are expressions of possibilities."

Another very important point in connexion with averages must be borne in mind. It is, that if an *average of averages*

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[1] *Loc. cit.* P. 487.

is taken, the number of units or facts included in each average *must be equal*; otherwise most erroneous results will be obtained.

The death-rates in Dublin, given above, will serve as an example. In 1864 the rate was 23; in 1865, 26; in 1866, 29; in 1867, 27; in 1868, 25; and in 1869, 24. Now, suppose we knew the average death-rate in the first four of these years, and also the average in the last two years, should we be justified in concluding that the sum of the two averages divided by 2 would give us a correct idea of the average death-rate of the whole six years? Certainly not. Let us see what the result would be.

$\frac{23+26+29+27}{4}=\frac{105}{4}=26{\cdot}25$, the average death-rate of the first four years.

$\frac{25+24}{2}=\frac{49}{2}=24{\cdot}5$, the average death-rate of the last two years.

Then $\frac{26{\cdot}25+24{\cdot}5}{2}=\frac{50{\cdot}75}{2}=25{\cdot}375$, the average of these two averages of *unequal* periods.

But the average of the six years is not 25·375, but 25·667, a figure which we get in either of two ways—(1.) by taking the average of the whole six years, thus :—

$\frac{23+26+29+27+25+24}{6}=\frac{154}{6}=25{\cdot}667$; or (2.) by taking the average of the averages of two *equal* periods of three years each, *i.e.* :—

$$\frac{23+26+29}{3}=\frac{78}{3}=26{\cdot}000, \text{ and } \frac{27+25+24}{3}=\frac{76}{3}=25{\cdot}334,$$

but $$\frac{26{\cdot}000+25{\cdot}334}{2}=\frac{51{\cdot}334}{2}=25{\cdot}667, \text{ Q.E.D.}$$

We are now in a position to apply the foregoing rules in practice. In the quarterly returns of births and deaths in large towns, published by the Registrar-General, the actual numbers of births and deaths registered are represented in annual ratios and percentages, or multiples of a percentage, of the population. For example: In the quarter ending July 4, 1874, the births registered in Dublin amounted to 2,365, "being equal to an annual ratio of 1 in 33, or 30 in every thousand of the population." How are these results obtained? By two simple proportions similar to those given above (Page 72). The population of Dublin is 314,666.

If the births registered in one quarter are 2,365, of course those registered in a year, *at the same rate*, would be four times as many, or 9,460. Then we have—

$$314,666 : 1,000 :: 9,460 : x = 30{\cdot}1 = \text{the annual birth-rate per } 1,000.$$

The percentage birth-rate is 3·01, or one-tenth of the above. To find the ratio of births to the total population, we have—

$$9,460 : 314,666 :: 1 : x = 33{\cdot}26; \text{ that is, 1 in } 33{\cdot}26.$$

In the Registrar-General's Weekly Returns, again, the deaths are given as representing an annual death-rate or mortality of so many per 1,000 of the population—*e.g.*, in the week ending August 8, 1874, the deaths in the Dublin District numbered 133, equal to an annual mortality of 22 in every 1,000 of the population—namely, 314,666. We have first to multiply 133 by 52, the number of weeks in a year. Then the proportion is as before—

$$314,666 : 1,000 :: 6,916 \ (i.e.,\ 133 \times 52) : x = 21{\cdot}98,$$
or nearly 2·2 per cent.

When extreme accuracy in the results is not required, we may discard decimal places, counting any decimal greater than or equal to ·5, or $\frac{1}{2}$, as 1·0, and any decimal less than ·5, as 0. Thus, in the foregoing examples the Registrar-General writes "1 in 33" instead of "1 in 33·26;" "30" instead of "30·1" (both ·26 and ·1 being less than ·5), and "22" instead of "21·98" (·98 being greater than ·5, and accordingly regarded as 1, a whole number).

It has been shown that averages can be employed only within certain limits to indicate the probable future recurrence of a death-rate, or of any other fact, the subject of statistical inquiry. One reason for this has been before explained—namely, the unreliable nature of averages deduced from a small number of facts or observations. But other conditions have to be discussed. Let us take an example. We are desirous of comparing the vital statistics of London in 1874 with those of London in the previous ten years.

In the week ending August 8, 1874, the deaths in the

metropolis were 1,505, and the average number of deaths in the corresponding week of the preceding ten years was 1,638·6. Are we to conclude, then, that in 1874 the deaths fell exactly 133·6 below the average? If the population had remained stationary, this would be a fair inference from the data. But the average population of London in the ten years ending 1873 was 3,092,336, whereas in 1874 the estimated population had risen to 3,400,701. We have, then, the proportion—

3,092,336 : 3,400,701 : : 1,638·6 : 1,802=the average number of deaths corrected to increase of population.

So that the deaths in this first week of August, 1874, fell 297 short of the corrected average of the ten preceding years. In comparing, then, the mortality statistics of a locality at one period with those at another, fluctuations of population have to be taken into account, besides many other circumstances—such as prosperity or the reverse, peace or war, mildness or severity of the weather, social condition, occupations, etc., of the people, completion of drainage works, improved water supply, and so on.

It may also become necessary to compare the vital statistics of one place with those of another. Apart from the consideration of all the conditions just spoken of, we have in this case to bear in mind the relative proportions of the populations of the places compared.

For instance, the average number of deaths in London in the first 20 weeks of 1874 was 1,465·6 ; in Dublin the corresponding number in the same period was 164·1. From these statements merely we cannot compare the death-rate in the two cities. But if we take the population of London to be eleven times that of Dublin, and multiply 164·1 by 11, we have a direct comparison instituted.

$$164{\cdot}1 \times 11 \doteq 1{,}805{\cdot}1,$$

a figure considerably above that of the average weekly deaths in London—namely, 1,465·6. Or we can take the converse, and divide 1,465·6 by 11. Then $\frac{1{,}465{\cdot}6}{11} = 133{\cdot}2$, the weekly number of deaths in Dublin corresponding to 1,465·6 in London. If we wish for extreme accuracy in the calculation, since London is not quite eleven times as

populous as Dublin, we must make the following proportional statements :—

314,666 (the population of Dublin) : 3,400,701 (the population of London) : : 164·1 (the average weekly deaths in Dublin) : 1,773·5 (the corresponding average weekly deaths in London) ; and

3,400,701 : 314,666 : : 1,465·6 (the average weekly deaths in London) : 135·6 (the corresponding average weekly deaths in Dublin).

Here we have two interesting and valuable results. We find, first, that if the mortality in London had been as high in the period under discussion as it had been in Dublin, 1,774 people, instead of 1,466, would have died in the former city every week ; secondly, that if the mortality in Dublin had been as low as that in London, only 136 deaths, instead of 164, would have occurred weekly.

In comparisons between the death-rates of different places, another very important factor has to be noticed—*the density of the population* in each place, or, in other words, the relative densities of the populations. But this topic will more fitly be considered in a subsequent chapter.

Statistical facts are sometimes graphically represented in a diagram, a certain space drawn to scale being used to express a number :—

"Two lines, one horizontal (axis of the abscissæ) and the other vertical (axis of the ordinates), form two sides of a square, and are then divided into segments, drawn to scale—vertical and horizontal lines are then let fall on the points marked ; the axis of the ordinates representing, for example, a certain time, and the axis of the abscissæ representing the number of events occurring at any time. A line drawn through the points of intersection of these two quantities forms a graphic representation of their relation to each other, and the surface thus cut can be also measured and expressed in area if required, or the space can be plotted out in various ways, in columns, pyramids, etc. In the same way circles cutting radii at distances from the centre, drawn to scale, are very useful ; the circles marking time (in the example chosen), and the radii events, or the reverse. Such graphic representations are most useful, and allow the mind to seize more easily than by rows of figures the connexion between two conditions and events."[1]

Registration of disease has not yet been introduced into these countries—at least to any extent; and notwithstanding the comparative value of a system of death-registration, we

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[1] Parkes—*Loc. cit.* P. 487.

are still without reliable data for gauging the *morbility* of the population, except once in every ten years, when the census supplies such data. A correct determination of the morbility would give the earliest possible information as to the outbreak of an epidemic or the prevalence of an endemic disease, and would allow us to estimate the fatality of either an epidemic or an endemic disease, and the varying ratio of cases to deaths in successive outbreaks.

An organisation for the registration of disease is in operation in many foreign countries. The College of Health at Stockholm, for example, receives monthly and yearly reports of the health of Sweden from a corps of medical men, styled provincial and district physicians. Accurate returns of the prevalence of disease are included in these reports. There can be little doubt that before long some such system will be introduced into the United Kingdom. The Local Government Board for Ireland, in issuing their Sanitary Orders under the *Public Health (Ireland) Act*, have recognised the importance of, and necessity for, compiling statistics of disease, although their order on the subject is rather indefinite.[1]

In connexion with this subject, the *law of the duration of sickness* at different ages, as stated by M. Villermé after documents belonging to the Highland Society of Scotland,[2] may be mentioned here. From the results embodied in the appended Table, the Society concludes that under 21 years of age the mean annual duration of diseases may be estimated at 3 days or thereabouts, and under 70 years at about 4 months, or 16½ weeks.

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[1] *Cf.* P. 25.
[2] *Annales d'Hygiène.* Janvier, 1830.

TABLE I.

Age Years	Weeks of Illness for an individual	Age Years	Weeks of Illness for an individual
21	·575	55	1·821
25	·585	57	2·018
30	·621	60	2·346
35	·675	63	3·100
40	·758	65	4·400
45	·962	67	6·000
50	1·361	70	10·701

It is generally admitted that the estimate of the duration of sickness published by the Highland Society is too low. Mr. Ansell has compiled Tables based upon an examination of the Records of various Friendly Societies in the 5 years, 1823–1827, which give a higher average amount of sickness; and Mr. Neison has similarly investigated the subject with a like result. The following Abstract enables us to compare the relative merits of the conclusions arrived at:—

Annual Amount of Sickness to each Person, expressed in Weeks.

Age	Highland Society	Ansell	Neison. Average of Rural, Town, and City Districts in England
20	·575	·776	·840
30	·621	·861	·911
40	·758	1·111	1·181
50	1·361	1·701	1·960
60	2·346	3·292	4·166
70	10·701	11·793	14·039

CHAPTER VI.

Statistics of Births.

Influences to which Man is subject—Birth-rate—Prolificness of a Population—Prolificness of Marriages—Statistics of Births—Influence of *Sex*, controlled by City Life and Illegitimacy—Explanations of the excess of Male Births—Influence of *Age;* of *Place;* of *Periods*—Dependence of Birth-rate on Marriage-rate—Influence of *Seasons; Hours of the Day; Professions, Mode of bringing up, &c.; Morality*—Illegitimacy—Influence of *Political and Religious Institutions*—Still-Births.

M. Quetelet, in his *Physique Sociale*, includes the influences to which mankind is subject in the two following groups:—

(1.) Purely *physical* or *natural*,[1] such as (*a*) Sex, (*b*) Age, (*c*) Place, (*d*) Periods, (*e*) Seasons, (*f*) Hours of the Day.

(2.) *Moral* or *disturbing*,[2] such as (*a*) Profession, Mode of bringing up, etc., (*b*) Morality, (*c*) Civil and Religious Institutions.

He points out also that by the operation of this second group man is distinguished from the lower animals.[3] It must not be forgotten that the word "man" is here used in the sense indicated in Chapter V., as implying the species, or, in the words of Quetelet, *l'homme moyen*, in contradistinction to the individual man. It will be convenient in this and the next chapter to consider the beginning and ending of the life of man as subject to these groups of influences.

Birth-rate.—By this term is commonly meant the proportion of births which takes place each year to the total population of a country or district or town. This proportion may be expressed in either of two ways. Thus, we may

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[1] *Les causes naturelles.*

[2] *Les causes perturbatrices.*

[3] "C'est par ses forces morales que l'homme se distingue des animaux, qu'il jouit de la faculté de modifier, du moins d'une manière apparente, les lois de le nature qui le concernent, et que peut-être, en déterminant un mouvement progressif, il tend à se rapprocher d'un état meilleur."—*Loc. cit.* Vol. i., p. 146.

say that the birth-rate in Dublin in 1873 was 1 in 35 of the population, or that it was 29 per 1,000 of the population. The proportions from which these results are obtained are respectively :—

(1.) 9,032 (the number of births in 1873) : 314,666 : : 1 : 34·7.

(2.) 314,666 : 9,032 : : 1,000 : 28·7.

It will be seen from the following pages that the height of the birth-rate is usually a valuable indication of the prosperity and physical welfare of a community. A high birth-rate *in the presence of a low death-rate* implies that a population is living under the most favourable conditions possible as regards health, vigour, and longevity. *Health*, because a larger proportion of the population survives to a marriageable age—*vigour*, because more individuals are fitted to propagate their species—*longevity*, because the more numerous the births are to a marriage, the greater the presumption that a long interval exists between the mean period of marriage and the mean period of death. At the same time, unless a high birth-rate be coincident with a large area of habitable country and material prosperity sufficient to support the rapidly-increasing population, the consequences to national health will be very serious in the end. Dr. Acland writes :[1]—

"It is not possible to reflect on this subject without recognising the truth of the proposition that, making every allowance for the action of counteracting causes, excessive development of a population on a limited area like Great Britain must in the end be disastrous to the nation, unless, first, the population can be kept healthy, and, secondly, the commodities of life are obtainable to a commensurate extent. The arithmetical bearings of this point have been worked out by Mr. Samuel Ruggles, in a report to the President of the United States.

"The conclusion, then, seems almost forced upon us, that whenever our population increases beyond the power of our area to maintain it,

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[1] *National Health.* P. 25.

two effects will follow, more especially in times of commotion—increased pauperism, increased disease among the adults. If philanthropic or legislative efforts succeed, there will be added the rearing of wretched children, incapable in body and mind ; multiplication of lunatic asylums, reformatories, and workhouse schools, and crushing taxation of the industrious, capable, and healthy.

"Conversely, if the preventive checks of Malthus, and especially education (in which I place first, moral culture, however attained), can be brought into operation, two results might be expected—first, that the population may be kept in some check ; and secondly, that the internal administration of the country may be greatly improved by the political sense of the masses. Through these two causes there may be hope for the nation. It is doubtless true, first, that in the history of the world we have seen nations almost brought to a stand by epidemics, as, for instance, in various parts of Europe during the fourteenth century by the astonishing ravages of Black Death; secondly, some check is induced by wars ; and thirdly, an excessive mortality of children produces the same results. The operation of these natural checks is eminently uncertain, and to count upon them as substitutes for self-control, prudence in marriage, and good political administration, is deliberately to substitute the instinctive life of brutes or savages for the progressive experience, the reason and morality of the human race, and to accept the destiny which such life brings with it. When savages and brutes meet in conflict with civilised man, that destiny has usually been extinction."

The annual number of births enables us to estimate the prolificness of a country. But it must be remembered that in the general birth-rate are included the births of illegitimate as well as of legitimate children. If we except the former, we arrive at the prolificness of marriages—a subject of rather less importance to the State in some respects. As Quetelet points out, the question of the production of illegitimate children is one of deep interest. First, because illegitimacy brings individuals into the world who are without the means of subsistence, and who will thus become a burden to the State; and, secondly, because the debt thus incurred is likely to remain unpaid, such individuals being generally feeble and seldom reaching a healthy maturity.

According to the Registrar-General's (England) Report for 1871, the birth-rate in that year for England and Wales

was 35·0; for Scotland, 34·5; and for Ireland only 28·1 per 1,000 of the population.[1]

In Dublin the birth-rate of the same year was 29 per 1,000; in London, 34·5; in Glasgow, 39; and in Edinburgh, 34. As regards England and Wales, in the ten years, 1851–60, the average annual birth-rate was 34·2; in the ten years, 1861–70, the rate increased to 35·2. From these figures, we may look upon the annual birth-rate as nearly 35 per 1,000 of the population, or 1 in 29.

Turning to the question of the prolificness of marriage, we find that in England five children are, on an average, born to every marriage; in France the average fecundity is 3·2 children; in Paris, 2·3. It is computed that three out of the five children to a marriage in England attain a marriageable age.

Statistics of Births—(1.) *Influence of Sex.*—It has long been observed that more boys than girls are born into the world. Quetelet has compiled a table, based on observations collected by Captain Beckes (whose numerical units are *seventy millions* in number), showing the proportion of boys to girls born in the different countries of Europe. In Russia there are 108·9 boys to 100 girls, and in Great Britain, 104·7. The mean for Europe is 106 boys to 100 girls. The Registrar-General of England[2] says:—"The birth-registers have established the fact that more boys than girls are born, the proportion over a series of years being, in round numbers, 104 boys to 100 girls. Sometimes, but only twice within the last twenty years, the ratio becomes 105 to 100; while on two occasions (1871 and 1868) it has fallen below 104 to 100."

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[1] Alluding to the great discrepancies between the birth, marriage, and death-rates of Ireland and those of England and Scotland, the Registrar-General observes that they show "either that registration in Ireland is extremely defective, or that the constitution or the circumstances of the population is altogether different from that of Great Britain."

[2] *Thirty-fourth Annual Report.* P. 16.

From Belgian statistics, *city life* seems to exercise a decided influence in lessening the excess of male births. From 1815 to 1824 the ratios were—in the cities, 106·66, in the country, 106·96 boys to 100 girls; from 1825 to 1829 the corresponding ratios were 105·29 and 106·10 boys to 100 girls. We have a good example of this in the case of our own country also. Thus, in the Dublin Registration District, within the ten years, 1864–73, there were born 44,286 boys and 42,365 girls, or 104·5 boys to 100 girls. In 1873 the proportion fell to 102·9 to 100, the numbers being 4,580 boys and 4,452 girls. In all Ireland, within the five years, 1868–72, 381,681 boys and 361,272 girls were born, or 105·6 boys to 100 girls. *Illegitimacy* is also found to re-act upon the returns of male and female births in the same direction. In England, in 1871, 103·5 males were born in wedlock to 100 females so born; while 103·1 males were born out of wedlock to 100 females so born. This effect of illegitimacy Quetelet considers to be due to the customary delay in registering illegitimate births, the greater mortality of boys soon after birth thus tending to equalise the sexes in the lists of registered births.

Various explanations of the occurrence of an excess of male over female births have been offered.

M. Prevost[1] attributes it to the preference so generally shown to infants of the male sex, which tends to prevent the increase of the family after the birth of a boy—the parents' desire having been fulfilled in this event. Quetelet regards this explanation as quite inadequate. M. Giron de Buzareignes[2] considers that the *employment* of the parent is a determining cause. He divides society into three classes—the first composed of persons whose occupation tends to develop physical qualities; the second, of persons whose employment enervates their powers; and the third, of those whose occupations are of a mixed order. According to this view, the proportional number of male births should be greater than the average in the agricultural class, and less than the average amongst those devoted to commerce and manufactures. M. Bickes[3] maintains that the production of a plurality of male children depends on physiological peculiarities in races and communities. Hofacker[4] has compiled tables from which it would appear that (1.) when the mother is older than the father, fewer boys than girls are born; (2.) when the parents are of

[1] *Bibliothèque Universelle de Genève.* 1829. P. 140 *seq.* Quoted by Quetelet.
[2] *Bulletin de M. de Férussac.* Vol. xii. P. 3.
[3] *Annales d'Hygiène.* October, 1832. P. 459.
[4] *Annales d'Hygiène.* July, 1829. P. 537.

equal age, the sexes of the children are equal; and (3.) the more the age of the father exceeds that of the mother, the larger is the proportion of boys. In *The Law of Population*,[1] Sadler arrives at conclusions which corroborate those of Hofacker, and explain those of Giron de Buzareignes. He finds that (1.) on the mean of the total number of births, the sex of the father or of the mother will preponderate according to the side on which the excess of age exists; (2.) the sex which preponderates will have a mortality dependent on the period separating the ages of the parents, so that the sexes will be balanced in number towards the usual epoch of marriage; and (3.), as a consequence of (1.), the proportion of male children is less in the English manufacturing towns than in the country districts. Quetelet believes that the most influential determining cause of an excess of male births is the difference of age of the parents. As a general rule throughout Europe, men are five or six years older than women at the time of marriage, so that the preponderance of male births will be almost exactly that established by the researches of Hofacker and Sadler, who give the ratio of male to female births as 103·5 to 100 when the father is from one to six years older than the mother.

(2.) *Influence of Age.*—The fecundity of marriages is remarkably controlled by the age of those married. Quetelet draws the following conclusions, based chiefly on tables compiled by Sadler in his work already quoted:—

(I.) Too early marriages induce sterility and produce children whose chance of surviving is diminished.

(II.) A marriage, if not barren, produces the same number of births, no matter what the age at which it took place, provided that this age does not exceed about thirty-three years in the case of men, and twenty-six in the case of women—after these ages the number of children capable of being produced diminishes.

(III.) From this result and from a consideration of the *probability of life*, we may conclude that the greatest fecundity is observed before thirty-three years in men and twenty-six in women.

(IV.) Account being taken of the respective ages of the married, we find that, all things being equal, the most pro-

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[1] Vol. ii. P. 343. London, 1830.

ductive marriages are those where the husband is at least as old as the wife, or older, without, however, exceeding her much in age.

From the consideration of Belgian statistics, it appears that the greatest number of marriages, as well of men as of women, takes place between the ages of 26 and 30 years—the maximal falling at 29 years for men and after 27 years for women. Quetelet remarks on this that men should therefore have their first-born towards the age of 30 years, women towards 28, and that these ages should give the duration of a generation in Belgium—they are also the duration of mean lifetime (de la vie moyenne). In England, in 1871, the mean age at marriage or re-marriage was for all the men 27·9 years, and for all the women 25·7 years. The Registrar-General says that no perceptible variation had taken place in these numbers during the five years ending 1871.

(3.) *Influence of Place.*—The data are incomplete and unreliable. M. Benoiston de Chateauneuf,[1] in a paper quoted by M. Quetelet, divides Europe into a *northern* and a *southern* climate—the latter extending from 40° N.L. to 50° N.L., and the former from 50° N.L. to 67° N.L. His statistics go to show that 100 marriages gave an average of 430 births in the northern district, and of 457 in the southern district. As examples of extreme climates, he quotes Portugal, where 5·10 children are born to every marriage; and Sweden, where only 3·62 children are so born. Quetelet justly observes that these results are largely due to the tardy period of marriage in the North, and to the precocity of southern countries.

(4.) *Influence of Periods.*—Naturally, the birth-rate rises and falls subsequently to corresponding fluctuations in the marriage-rate of a country. In his "Eighth Annual Report of Births, Deaths, and Marriages in England," the Registrar-General sums up the causes of these fluctuations in this pithy sentence:—"In fine, the great fluctuations in the marriages of England are the results of peace after war, abundance after dearth, high wages after want of employment,

[1] *Annales des Sciences Naturelles.* 1826.

speculation after languid enterprise, confidence after distrust, national triumphs after national disasters." He adds:—"The causes that increase and the causes that diminish marriage differ in energy; they admit of various combinations; they sometimes neutralise each other; and the marriages express the result of all those forces on the public conduct of the people." "It is remarkable," observes Quetelet, "that epidemics, famines, and all great pestilences, exercise a marked influence not only on the mortality, but also on the number of marriages and of births."

The statistics of marriages *registered* in Ireland since 1864 bear out these observations in a striking manner. The numbers were:—1864, 27,373; 1865, 30,688; 1866, 30,151; 1867, 29,796; 1868, 27,753; 1869, 27,368; 1870, 28,835; 1871, 29,008; 1872, 27,114. Now, 1866 was the cholera year, and 1867 was both inclement and unhealthy. A great falling off in the number of marriages followed. This was checked by a succession of fine and comparatively healthy years—1868-1870. But the small-pox epidemic then broke out, and a rapid decline in the marriage-rate again ensued. The relation of the birth-rate to the marriage-rate is very interesting. In 1864 the registered births in Ireland gave a ratio of 1 in every 42·4 of the population; in 1865, of 1 in 39·9; in 1866, of 1 in 39·6; in 1867, of 1 in 40·2; in 1868, of 1 in 39·7; in 1869, of 1 in 37·9; in 1870, of 1 in 36·7; in 1871, of 1 in 35·6; and in 1872, of 1 in 36·0. The registration in 1864 was very defective.

(5.) *Influence of Seasons.*—The births registered in the first six months of the year exceed those registered in the last six. To this rule there appears to be no exception on record. "The birth-rate is usually highest in the first three months, or the winter (March) quarter of the year. Taking the mean of each of the quarterly rates during 34 years, the average annual births to 1,000 persons living were 35·4 in the March, 35·1 in the June, 32·5 in the September, and 32·3 in the December quarters. On ten occasions in the last 30 years the birth-rate in the second quarter was higher than in the first; similarly there were 10 fourth quarters of higher birth-rate than the third." [1]

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[1] Registrar-General of England. *Thirty-fourth Annual Report.* P. 17.

The result of Quetelet's researches on this subject, published in 1824 in the *Nouveaux Mémoires de l'Académie de Bruxelles*, is that the numbers of births and of deaths increase and decrease alternately, attaining their *maximum* towards the month of January in the case of deaths, and towards the month of February in the case of births, and their *minimum* about six months later—namely, in July. The maximum of births in February pre-supposes the maximum of conceptions in May, when the vital powers regain all their activity after the rigors of winter.

According to M. Villermé,[1] the same holds good, *mutatis mutandis*, for Buénos Ayres, in the southern hemisphere. In Ireland, in the five years ending 1873, the average annual number of births was 148,211. Of these, 80,186, or 54·1 per cent., took place in the first six months, and only 68,025, or 45·8 per cent., in the last six months. In the quarter ending March 31, 40,015 births were registered ; in that ending June 30, 40,171 ; in that ending September 30, 34,061 ; and in that ending December 31, 33,964. The equivalent annual rates per 1,000 of the estimated population were, for the whole year, 27·5 ; first quarter, 29·7 ; second quarter, 29·8 ; third quarter, 25·3 ; fourth quarter, 25·2.

(6.) *Influence of Hours of the Day.*—Several statisticians have investigated this curious subject. From observations extending over a long series of years at the Maternité de l'Hôpital Saint Pierre de Bruxelles, Quetelet estimates that 126 children are born at night for 100 born during the day; that is, 5 by night for 4 by day. Dr. Buek, of Hamburg, finds that of 1,000 children, 312 are on the average born between midnight and 6 a.m.; 249 between 6 a.m. and noon; 183 between noon and 6 p.m., and 256 between 6 p.m. and midnight. These numbers give the ratio of 131 births by night to 100 by day.

(7.) *Influence of Professions, etc.*—On this point we possess no satisfactory information. M. Benoiston says it may be laid down as a law that the population of States is always proportional to their producing power as regards the

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[1] *Annales d'Hygiène.* Quoted by Quetelet.

necessaries of life. A high birth-rate is consequently never observed amongst a poor and oppressed people, without agricultural pursuits, industry, and liberty. It is a well-known fact that at San Domingo, in 1788, *three* marriages produced only *two* children amongst the blacks, while *each* marriage gave *three* children amongst the white population. To the same principle we may attribute the gradual extinction of aboriginal races, like those of Australia and North America. In 1865 only six of the aborigines of Tasmania survived, and no children had been born among them for many years.

(8.) *Influence of Morality.*—The number of conceptions is diminished by *concubinage*, as is exemplified in the barrenness of prostitutes, by *too early sexual intercourse*, and by *habits of order and prudence.* These last tend to lessen the number of marriages, and so react on the birth-rate.

Speaking of this, Quetelet says :—"The great fecundity of Ireland has been cited in illustration of the effect exerted on fecundity by discouragement and imprudence." In the province of Guanaxuato, in Mexico, the annual birth-rate is 100 for every 1,608 of the population, and the death-rate 100 for every 1,970—an excessive mortality, an excessive birth-rate, and an excessive poverty being there united. "Many political economists," Quetelet observes, "have maintained with reason that the most efficacious method of preventing a superabundant population is to diffuse knowledge and sentiments of order and of prudence."

Illegitimacy.—In 1871, 44,775 illegitimate births were registered in England, amounting to 5·6 per cent. of the total births registered. In the ten years, 1851-60, they averaged 6·5 per cent.; in the following ten years, 6·1 per cent., thus showing a steady and substantial decline. Mr. Babbage[1] gives the proportions in several countries and places as follows :—

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[1] A letter to the Right Hon. T. P. Courtenay.

France, for 1,000 legitimate,		69·7	illegitimate births.
Naples (kingdom)	,,	48·4	,,
Prussia	,,	76·4	,,
Westphalia	,,	88·1	,,
Westphalia (towns)	,,	217·4	,,
Montpellier	,,	91·6	,,

On an average of many years, the ratio in Berlin has been 1 illegitimate for 7 legitimate births, or 143 illegitimate for 1,000 legitimate births.

(9.) *Influence of Political and Religious Institutions.*—The rapid increase of the population observed in England and the United States of America, of late years, affords striking evidence of the influence for good on a nation of material prosperity and of a wise and liberal Constitution. But it is only in the presence of such that an increased fecundity is to be looked on as a favourable sign in the history of a nation. When the means of supporting life are scanty, a high birth-rate is immediately followed by an increased death-rate. An extreme instance of this has already been referred to—namely, the province of Guanaxuato, in Mexico.

M. Villermé[1] shows that in almost all Roman Catholic countries the season of Lent lessens the number of conceptions.

Still-births.—Although still-births have not hitherto been registered in the United Kingdom, medical statisticians are very generally of opinion that they should be so; and it is likely that, before long, the registration of children who have died before performing the act of respiration[2]—"les morts-nés, dont l'existence équivoques semble appartenir autant aux annales de la vie qu'à celles de la mort"[3]—will be made compulsory by law. Statistical tables, based on returns of eight millions of births, show that the proportion of still-

[1] *Annales d'Hygiène.*

[2] Taylor. *Medical Jurisprudence.* 1865. P. 946.

[3] Quetelet. *Loc. cit.* P. 221.

born among legitimate children varies from 1 in 18 to 1 in 20 of all the births. At Berlin, the mean proportion, from 1758 to 1821, was 1 in 19·8 births. Dr. Casper[1] thinks the number of still-born is proportionally greater in towns than in the country, and Quetelet says that this view is borne out by the statistics of West Flanders for the years 1827–1830 inclusive. The ratios were—for the towns, 1 still-birth in 20·4 births; for the country, 1 still-birth in 38·2 births.

The mortality among boys is greater than that among girls, in the proportion of 140 to 100, while (as we have seen) the total males to females born are only as 105 to 100. This is ascribed to the greater risk of injury to the large male head and brain during delivery. Of 2,597 still-born children in West Flanders, 1,517 were of the male sex, and 1,080 of the female sex—the ratio being 14 : 10, or, as above, 140 : 100. Of 4,032 still-born children in Berlin, 2,289 were males, and 1,743 females—the ratio being 131 to 100. At Amsterdam, the means of the years 1821–1832 inclusive, give 244 male still-born, and 186 female still-born—the ratio is 13 to 10, and 1 still-born for every 16·9 births. In Paris (1823-1832) the ratio of still-born boys to girls was 12·2 to 10. As regards the influence of season, Belgian and German statistics prove that the number of still-births is highest in winter and early spring. Illegitimacy causes a marked increase of still-births, the proportion being 1 in 8 or 10. In Göttingen, among legitimate children, there were 3 still-born to 100 births, and among illegitimate 15 to 100. In Berlin, the corresponding proportions were 5 to 100, and 15 to 100, respectively. Syphilis in the mother also increases the number of still-births. Quetelet says that, at Hamburg, of 18 illegitimate children of diseased prostitutes, 6 were dead-born, and in another house in the same city there were 11 still-births among 93 births. Still-births are much more numerous in first than in subsequent confinements.

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[1] *Ueber die Sterblichkeit der Kinder in Berlin.* 1825.

CHAPTER VII.

Statistics of Deaths.

Registration of Deaths—Census Enumerations—Death-rate, how expressed—Influence of *Sex* on Mortality, or Death-rate—Influence of *Age;* Law of Mortality; Demoivre's Hypothesis; Mean Duration of Life; Expectation of Life; Probable Duration of Life; Life-Tables; Willich's Formula for determining the Expectation of Life; Mortality of Children; Centenarianism—Influence of *Place;* Climatology; City Life as compared with Country Life; Physical Configuration of a Locality; Sanitary Conditions—Influence of *Periods;* Scarcity; War; Pestilence—Influence of *Seasons;* Effects of Cold and Heat—Influence of *Hours of the Day; Professions, Mode of bringing up, &c.; Civil and Religious Institutions, &c.*

In order to arrive at an accurate estimate of the birth-rate or of the death-rate of a population, it is necessary to have a complete system of registration of births and deaths, and, in addition, a correct enumeration, or census, of the population. Any deficiency in either the registration or the census will lead to erroneous estimates of the birth and death rates.

In England, Registration was introduced in 1836, by the Acts 6 & 7 Will. IV., c. 85 & 86, and on the 1st of July, 1837, the system was set working. Some idea of the work done since then may be gathered from the Registrar-General's Thirty-fourth Annual Report, in which this passage occurs :[1]—

"The records of this office, for the period of 34½ years, extending from the middle of 1837 to the end of 1871, comprehend, in respect of their relation to the three great events of life—birth, marriage, and death—upwards of *forty-seven million* NAMES ; each name being inscribed in an Alphabetical Index, prepared quarter by quarter promptly as the certified copies reach this office, and so arranged as to give the utmost facility for reference. All that is necessary on the part of an inquirer to ensure the immediate production of an entry of marriage, birth, or death, is that he should give the year in which the event took place, and the correct name of the person to whom it relates."

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[1] P. xx.

In Scotland, a system of Registration of Births, Marriages, and Deaths was introduced in 1854, by the Act 17 & 18 Vic., c. 80, and in Ireland a similar system was introduced in 1863, by the Act 26 Vic., c. 11. Since January 1, 1864, registration has been carried out in this last-named country.

In modern times the word "Census" has been used to denote far more than was included in its ancient and original meaning. It is, indeed, a "counting" of the people, but it also includes a vast amount of statistical information as to the sex, age, profession, wealth, and general condition of the individuals who are counted. In Great Britain the first complete census was that taken in 1801, and since then the population has been numbered every ten years. The first complete census of Ireland was taken in the summer of 1821, and since that time there have been decennial enumerations of the population.

Knowing the population of a country or city, the mortality, or death-rate, is expressed by the ratio, to that population, of the deaths which occur—this ratio being represented, in the same way as the birth-rate (see p. 84), as 1 in so many of the population, or so many per 1,000 of the population. Thus, the death-rate of Dublin in 1873 was 1 in 38, or 26 in every 1,000 of the population. It may be laid down as a law that the number of births exceeds the number of deaths. This is true, at all events, of all countries for which there are statistics on the subject, and it holds good also in the case of cities, with a very few exceptions. The mortality of a country is even a more important matter for investigation than its birth-rate, for, as Quetelet well observes, the prosperity of nations should consist less in the *multiplication* than in the *preservation* of the individuals which compose them. Unless those born survive to such an age as will enable them to repay, by their exertions, the debt incurred to the State during their years of infancy and childhood, a serious infringement of the material prosperity of the State will ensue.

Quetelet gives a striking example of this. Estimating the cost of supporting a child to the age of from 12 to 16 years, at a minimum of 1,000 francs (about £40), and assuming that there are annually born in France 960,000 children, of whom *nine-twentieths*, or 432,000, die prematurely, he says:—"The expense which they have occasioned, without counting the time devoted to them, represents, *at a minimum, the enormous sum of 432 millions of francs*"—that is, £17,280,000 sterling.

Statistics of Deaths.—(1.) *Influence of Sex.*—In England the mean annual rate of mortality per 1,000 of males, in the thirty-four years, 1838–1871, was 23·3; the corresponding death-rate of females, during the same time, was only 21·5.

"The mortality of males is invariably higher than that of females. Throughout the twenty-five years, 1838–1862, male mortality in England never fell so low as 2·100 per cent., the lowest being 2·136, in 1856; while that of females was, in eleven years out of the twenty-five, below 2·1. In 1856, it was 1·969. . . . On an average of the twenty-five years, 1838–1862, out of 100 males, there died, annually, 2·309; while out of 100 females, there died, annually, 2·143; for every 100 females that died, there died 103 males."[1]

In 1871, in England, taking the deaths alone, the proportion of males to females dying was as 107 to 100; but, having regard to the larger number of females in the population, out of which the deaths occurred, the Registrar-General calculates the proportion of male to female deaths, out of *equal numbers* of both sexes living, as 112 to 100. In infancy, Quetelet assigns the ratio of male to female deaths as 3 to 2 *before birth*, 4 to 3 during the *first two months* after birth, 5 to 4 during the *third, fourth, and fifth months.* After the eighth or tenth month the difference almost disappears. He concludes that some particular cause of death exists which singles out, by preference, male children before and immediately after birth, and he holds that it is impossible to attribute this greater mortality to the excess of male over female births, as the proportion of these last is scarcely 20 to 19. His conclusions on the question of sex are as follows:—"At birth, more males than females die; about two years of age the mortality of the two sexes becomes nearly the same. That of the females then increases, the preponderance becoming very perceptible between the ages of fourteen and eighteen, that is *after puberty.* Between twenty-one and twenty-six years, the period *of the most active passions,* male mortality exceeds female mortality. From twenty-six to thirty, the period of *marriage,* the mortality of both

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[1] Chambers' Encyclopædia. Art.: *Vital Statistics.*

sexes is almost identical, but that of women becomes more pronounced throughout the period of *fecundity*, after which it again diminishes, the two sexes ultimately dying out in the respective proportion in which mortality has left them."

The mean result over the whole of life is in favour of female life. It is worth noting that female assured life is not better than male assured life, although female annuitants live longer than male annuitants. The perils incident to female life during the child-bearing period go far to explain this apparently strange fact.

(2.) *Influence of Age.*—"Of all the causes which modify the mortality of man, there is none which exercises a greater influence than age."[1] The first Table of mortality was constructed by the astronomer Halley, in 1693, and was based on documents relating to the town of Breslau. This led to the investigation of "The Law of Mortality." Theoretically, the law of mortality is a mathematical relation between the numbers living at different ages; and it has been attempted to lay down such a mathematical relation. Thus Demoivre's hypothesis, that out of 86 persons born, one dies every year until all are extinct, is a theoretical law of mortality. A Life-Table, on the contrary, is a practical law of mortality, since it gives the actual numbers surviving at the end of each year. The Mean Duration of Life (*Vie Moyenne*) is the *expectation of life* at birth. At any other age than birth, it is the expectation of life at that age (as taken from a Life-Table) added to the age (*Parkes*). It is further defined by Dr. Farr, in general terms, as the *mean time* which a number of persons, at any instant of age, will live after that instant. To express this idea, he uses the word *after-lifetime*, in preference to the term, introduced by Demoivre, *expectation of life.* The *age* plus the *after-lifetime* is equal to the *lifetime*, so that at birth the *after-lifetime* and the *lifetime* are the same thing. The Probable Duration of Life (*Vie Probable*) is the age at which

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[1] Quetelet. *Loc. cit.* P. 299.

a given number of children born simultaneously will be reduced one-half.

Immediately after birth, the probable duration of life is, in Belgium, forty-two years in; other words, after the lapse of forty-two years, the number of children born at the same time will have been reduced to one-half. In England it is forty-five years. At the age of five years man attains the *maximal* probable duration of life, which is then, on the average, fifty-four years. That is to say, if he lives to attain his fifth year, the chances are equal that he will be, or will no longer be, alive fifty-four years afterwards (Quetelet). The probable duration of life in females is generally longer than that in males.

The *expectation of life*, or *after-lifetime*, is the true test of the health of a people, and we shall therefore have to speak of it at somewhat greater length.

Life-Tables, or Tables showing the expectation of life, have been constructed in two ways (Farr) :—

(1.) By a comparison of the *deaths* and the *living* at each age, which gives the rate of mortality and survivorship. This is the correct method.

(2.) From the *deaths alone*, or with reference only to the ages at which the deaths have taken place. This method is correct only if the population of the place is stationary; the births and deaths are equal, and there has been no disturbing migration for a century.

The principal life-tables used in the United Kingdom for insurance and annuity purposes are (I.) Dr. Price's *Northampton;* (II.) Dr. Farr's *New Northampton;* (III.) Dr. Heysham's *Carlisle;* (IV.) Mr. Finlaison's *Government;* (V.) Dr. Farr's *English;* and (VI.) *The Experience.* Of these, the English (Nos. 1 and 2) probably show the results of the average mortality of England more correctly than any of the others. No. 1 was based on the recorded ages of 15,914,148 living persons (the population of England by the census of 1841). No. 2 was deduced from the living in 1841 and from 2,436,648 deaths recorded in the seven years—1838-1844. Dr. Parkes has abridged the following table from Dr. Farr's Life-Tables :—

Expectation of Life in England.

Age	Males	Females	Age	Males	Females	Age	Males	Females
0	39·91	41·85	10	47·05	47·67	70	8·45	9·02
1	46·65	47·31	20	39·48	40·29	80	4·93	5·26
2	48·83	49·40	30	32·76	33·81	90	2·84	3·01
3	49·61	50·20	40	26·06	27·34	95	2·17	2·29
4	49·81	50·43	50	19·54	20·75	100	1·68	1·76
5	49·71	50·33	60	13·53	14·34			

From this it is seen that "after the first year the chances of living increase up to the fourth year; the fifth year is nearly as good, and then the chances of life lessen, but at first slowly, and then more rapidly; from 5 to 40 years of age the expectation of life lessens in the ratio of from $2\frac{1}{2}$ to $3\frac{1}{2}$ or $3\frac{3}{4}$ years for each quinquennial period."[1]

Willich gives this formula for determining the expectancy of life at any age x:—

$$\text{Expectancy of life} = \tfrac{2}{3}\,(80 - x).$$

For example:—

$$\text{Expectancy of life at 5 years of age} = \tfrac{2}{3}\,(80 - 5) = \tfrac{2}{3} \times 75 = 50 \text{ years.}$$

According to the English Life-Table, 119,594 children under one year of age die every year out of a total of 800,000 born, and in 17 large English towns, with an aggregate population of 6,207,870, the percentage of deaths of children under one year of age to the total mortality, was, in 1871, 26·2—19·2 out of every 100 children born dying before the age of one year. "By the English Life Table, of 100 children born, 15 die in the first year, 5 in the second, 3 in the third year, 2 in the fourth, and 1 in the fifth, making

[1] Parkes. *Loc. cit.* P. 488.

26 in the 5 years of age. Of the 15 who die in the first year, 5 die in the first month of life, 2 in the second, and 1 in the third."[1]

Quetelet's remarks on the influence of age on mortality may be summed up thus:—

(1.) During the first month after birth almost *one-tenth* of all the children born die, the mortality being four times as great as during the second month.

(2.) At five years the mortality suddenly lessens, and remains comparatively low until puberty.

(3.) What may be termed a "maximum of viability" is attained just before the age of puberty.

(4.) After puberty the mortality rises, especially in females.

(5.) Towards the age of 24, coincident with the full development of his passions and leaning towards crime (*penchant au crime*), a maximum of mortality is observed in man, but not in woman.

(6.) In man a second minimum is reached about 30, whereas the mortality of women exceeds that of men from 28 to 45 years (childbirth).

(7.) About 60 or 65, the viability of both sexes becomes very feeble, and the space of a century seems to limit human existence.

That this limit is not absolute is indeed true ; but the cases where centenarianism has been supported by documentary or other undoubted evidence are of exceedingly rare occurrence. Mr. W. J. Thoms, F.S.A., has met with four such instances out of 30 investigated by him, and the Registrar-General of England, writing in 1871, says that the experience of life assurance companies in that country supplies only one example of an insured life completing its hundredth year—namely, that of Jacob William Luning, whose death in 1870, at the age of 103 years, was clearly established by documentary evidence.

(3.) *Influence of Place.*—Under this heading we can only touch in the most general way on the relations of *Climatology* to Public Health. Some of the great truths connected with the subject will be further illustrated when we come to speak of the influence of season on mortality, and of climate generally. Quetelet, having collected and arranged all available data bearing on the point, has divided Europe into three regions, the mortality of each

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[1] Farr. *Mortality of Children in the Principal States of Europe.*

of which he expresses by the following ratios:—Northern Europe, 1 death annually in every 41·1 inhabitants; Central Europe, 1 in 40·8; Southern Europe, 1 in 33·7. It will be noticed from these figures that the mortality in Southern Europe is very much higher than that in the other two districts; and, also, that the mortality in Northern Europe is only *slightly less* than that in the Central region. Quetelet includes England in the Northern division, and as England has a comparatively very low mortality—1 in 45 on an average of 34 years [1]—the balance is thus turned in favour of the North. The central countries of Europe may, therefore, be regarded as having the lowest death-rate. Climate has much to do with this.

On the authority of M. Moreau de Jonnès, Quetelet gives the death-rates of several of the West Indian Islands, and of Bombay, as demonstrating the effect for evil of extremely warm climates on the mortality. There is no need to remind our readers of the notoriously deadly climate of the Tropical West Coast of Africa. At the same time, modern sanitary science has so triumphantly grappled with the evil influence of a hot climate, that Quetelet's estimate of the mortality in the East and West Indies has come to be greatly above the mark. Dr. Parkes, in his admirable work on Practical Hygiene, says [2]—"The history of sanitary science affords many striking instances of the removal of disease to an extent almost incredible, but no instance is more wonderful than that of the West Indies." He then graphically contrasts the former with the present condition of these islands as regards sanitation and death-rate. Moreau de Jonnès represented the mortality of Bombay as 1 in 20 of the population annually, that is, 50 per 1,000; but, in 1871, the registered death-rate in this city was only 20 per 1,000. Dr. Stokes, [3] writing in 1872, says:—"Since the introduction of sanitary measures, the death-rate of the three great capitals, and of the gaols, over the continent of India, are stated to have greatly lessened. Calcutta shows better than Liverpool or Manchester, and the death-rate of Bombay is less than that of London."

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[1] *Thirty-fourth Annual Report of the Registrar-General of England.* Table 2. P. lxi.

[2] Third Edition. P. 560.

[3] *State Medicine: A Discourse delivered before the University of Dublin, on Saturday, April 6th,* 1872. P. 32.

All this goes to prove that a hot climate tends materially to increase the mortality, and also that, happily, Preventive Medicine can as materially check this tendency. Iceland, on the other hand, has been cited as an example of a cold climate tending to augment the death-rate. The natives are shortlived, the probable duration of life being only 37 years for males, against 47 in Denmark, and almost 48 years for females against 50 in Denmark. But the most conclusive evidence of the influence of climate is met with in the case of England, which—as we have seen—has a mortality of only 1 in 45 of the population annually. A mean range of only 20° between summer and winter, cloudy skies, and frequent rains, with a high relative humidity, so far from acting injuriously on the health of a people, conduce to the greatest activity of mind and body, to a high standard of health, and to longevity. And these are the conditions of climate under which the inhabitants of Great Britain and Ireland live.

A still more salubrious climate is that of Tasmania, for there *all* the conditions are favourable to life—a mean annual range of only 17° F., an open winter, a temperate summer, ozone-laden sea-breezes at all seasons, clear skies, a moderate and evenly-distributed rainfall, and—what we cannot boast in our country—an absence of damp and fog in winter. The death-rate is remarkably low—only about 15 per 1,000 annually.

Under the heading "Influence of Place," is also to be considered the effect of city-life as compared with that of country-life on the mortality. In Belgium, prior to 1833, the death-rate in the towns was 1 in 37, that of the country districts was only 1 in 47. *As a rule*, the death-rate in large towns is higher than that in small towns. For example: in the seventeen largest English towns the mortality in 1871 was at the rate of 26·5 per 1,000 of the population annually, while in the fifty towns ranking next in size it did not exceed 24·8. Among the population of England and Wales, exclusive of these sixty-seven towns, the death-rate

was 21 per 1,000. If we look into the subject more closely, we find that these differences bear a fixed relation to *density of population*, and depend chiefly on the greater prevalence amongst crowded communities of zymotic or preventable diseases. In 1871 the seven chief zymotics—small-pox, measles, scarlatina, whooping-cough, diphtheria, fever, and diarrhœa—caused a death-rate of 6·5 per 1,000 in the seventeen largest towns in England, of 5·3 in the fifty other towns, and of 3·4 in the rest of England and Wales. The following Tables will further illustrate this point:—

TABLE IV.—*Showing the relation between Density of Population, General Death-rate, and Death-rate from Zymotic Diseases in* 13 *large Towns of the United Kingdom.*

	Population per Acre	Deaths per 1,000	Deaths per 1,000 from 7 principal Zymotics
(1)	(2)	(3)	(4)
London, - - -	41·8	24·2	4·5
Bristol, - - -	37·0	24·2	2·0
Birmingham, - - -	48·3	23·4	3·6
Liverpool, - - -	103·0	31·1	5·6
Manchester, - - -	84·5	30·4	6·0
Salford, - - -	23·9	28·5	7·5
Sheffield, - - -	11·2	26·5	4·6
Leeds, - - - -	12·3	27·2	3·6
Hull, - - - -	38·0	24·1	2·8
Newcastle-upon-Tyne, - -	25·5	28·0	6·0
Edinburgh, - - -	40·6	26·9	4·0
Glasgow, - - -	94·3	31·1	6·4
Dublin, - - -	33·1	25·4	4·4
Average, - - -	45·6	25·8	4·7

The foregoing Table is based on the Registrar-General's Returns for the five years, 1867–1871, inclusive.

TABLE V.—*Showing the relation between Density of Population, General Death-rate, Death-rate from Zymotic Disease, and Pauperism, in the London Registration Districts.*

	Population per Acre	Total Average Death-rate per 1,000 for 10 years	Death-rate per 1,000 from 7 Zymotics, 1871	Pauperism. 1 person receiving Out-door Relief in
(1)	(2)	(3)	(4)	(5)
Kensington,	39·3	19	4·5	36·9
Chelsea,	82·2	25	6·6	47
St. George's, Hanover-square,	74·1	19	4·9	30·2
Westminster,	235·7	23	4·2	40·1
Marylebone,	105·4	24	4·2	41
Hampstead,	14·3	17	4·4	122·2
St. Pancras,	81·5	22	4·8	25·5
Islington,	68·0	21	7·2	42·2
Hackney,	31·7	19	3·8	20·7
St. Giles,	217·0	28	4·7	36·7
Strand,	97·2	22	4·2	34·5
Holborn,	205·2	26	4·1	21·9
City of London,	104·6	19	4·0	13·9
Shoreditch,	196·8	26	6·1	30·4
Bethnal Green,	158·2	23	5·0	32·4
Whitechapel,	185·6	28	4·6	22·3
St. George's in the East,	198·8	29	5·5	11·9
Stepney,	99·9	27	4·2	19·3
Mile-End, Old Town,	136·8	24	4·7	29·0
Poplar,	39·4	24	4·5	25·6
St. Saviour's, Southwark,	151·3	29	4·9	22·6
St. Olave's, Southwark,	69·4	29	4·4	30·9
Lambeth,	51·8	23	5·3	32·2
Wandsworth,	10·7	20	5·3	27·4
Camberwell,	25·6	23	3·6	30·6
Greenwich,	26·6	24	5·2	21·7
Lewisham,	4·5	18	4·2	44·4
Woolwich,	9·9	—	6·7	12·6
Average,	41·8	24·2	4·4	27·8

The most common death-rate in country districts and small towns in all England and Wales is 20 per 1,000. In 1871 the number of deaths in a population of 22,712,266 was 514,879, equal to a death-rate of 22·6 per 1,000. If this rate could have been reduced to 20 per 1,000 by judicious

sanitation, no less than 59,234 lives would have been saved in one year.

In the third place the *physical configuration* of a country or district will influence its death-rate.

M. Bossi, in his *Statistique du Département de l'Ain*,[1] gives a good illustration of this. Grouping the registrations of the years 1802, 1803, and 1804, he divides the Department into four districts, according to their prominent physical characters. In the *Mountainous Communes* there was annually 1 death to 38·3 inhabitants; in the *River-bank Communes* 1 to 26·6; in the *Corn-sown Plain*, 1 to 24·6; and in the *country of Ponds or Marshes*, 1 to 20·8. The healthiness of the mountains here forcibly contrasts with the unhealthiness of the fenny districts. The evil influence of fens or marshes is well exemplified in the case of Vareggio,[2] a canton of the principality of Lucca, in which the mortality was very high until 1741, when the marshes were drained, but which has become one of the most salubrious, most industrious, and wealthiest of the cantons of Tuscany. Similar examples are the Scheldt and the Isle of Ely. The history of the last-named locality is of especial interest. From 1813 to 1830, inclusive, of 10,000 deaths, at all ages, 4,731 occurred before the age of ten years; the corresponding ratio for all England, in the same period, being 3,505 per 10,000. Writing in 1849, the Registrar-General of England says :—"The insalubrity of undrained land is seen now in England on comparing the mortality (2·45) of Ely, North Witchford, Whittlesey, and Wisbech in Cambridgeshire, at the mouth of the Nene, with the mortality (1·80 to 1·40 per cent.) of the high parts of Surrey, Sussex, North Devon, and Northumberland." In a Table illustrating the improvements of public health which result from proper works of drainage and water supply, and to which we shall have occasion to refer again, Dr. Buchanan gives the death-rate per 10,000, annually, in the town of Ely, as 228 in the years 1845–52 (before the sanitary works were carried out), and as 205½ in the years 1859–64 (after the completion of the works). Drainage diminished the mortality caused by phthisis to 47 per cent. of its former value; and in the year 1871 the death-rate from all causes, in the registration district of Ely, was only 13·5 per 1,000.

Lastly, the sanitary arrangements alone will exercise a marked influence on the death-rate of a locality. Thus, in 1867, the lowest death-rate in England was 11 per 1,000,

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[1] Quoted by Quetelet. *Loc. cit.* Vol. I. P. 292.
[2] Villermé. *Annales d'Hygiène.* Janvier, 1833. P. 9.

at Sandown, Isle of Wight, a small town, thoroughly drained and favoured with an abundant supply of pure water; while the highest, 70 per 1,000, was observed at Child's Hill, Parish of Hendon. The sanitary condition of this place was described as follows:—"There is no efficient drainage, and the open cesspools connected with the privies often overflow into the ditches, and discharge their contents into the River Brent."[1] Here, out of a population of 1,000, there were 70 deaths in 1867, mainly from enteric fever—one of the most preventable diseases among the zymotic group.

(4.) *Influence of Periods.*—The mortality is invariably markedly increased by the prevalence of seasons of scarcity, of war, or of pestilence. A very few words on each of these scourges of mankind will serve our present purpose.

(A.) *Scarcity.*—Writing in Ireland, we may best illustrate the effect of scarcity on the death-rate by an allusion to the famine of 1845–46–47. The partial failure of the potato-crop in 1845, its complete failure in 1846 and 1847 reacted, as is well known, with fatal effect. Not only was the staple food of the peasantry cut off, but pigs and poultry also perished, and owing to the enormous price of other kinds of food, immense multitudes were left to starve or to fall victims to disease.

The Census Commissioners of 1851 received the following returns of deaths in the years immediately preceding, during, and subsequent to the famine:—

1843 . . .	70,499	deaths.	
1844 . . .	75,055	„	
1845 . . .	86,900	„	(first famine year).
1846 . . .	122,889	„	(second „).
1847 . . .	249,335	„	(third „).
1848 . . .	208,252	„	
1849 . . .	240,797	„	
1850 . . .	164,093	„	

In the ten years, 1832–41, the total deaths from fever alone in Ireland

[1] *Quarterly Journal of Science.* January, 1868.

numbered 112,072 ; in the ten years, 1842-51, the number rose to 222,029.

(B.) *War.*—The disastrous influence of this element has been well shown in the case of the great Continental wars of recent years.

In 1866 the mortality in Austria rose from 31·0 per 1,000 in 1865 to 33·3, the actual number of deaths in the two years being 646,980 (1865), and 846,991 (1866). The mortality of the other combatant power, Prussia, rose similarly from 28·9 (1865) to 35·7 (1866), the number of deaths being 563,065 and 698,146 respectively. Part of the increase was, no doubt, due to cholera, which prevailed epidemically in both Prussia and Austria during 1866. No such competent parallel explanation, however, exists for the period of the Franco-German war of 1870–71, although an epidemic of small-pox coincided with it also. In 1869 the death-rate of France was 23·5 per 1,000 ; in 1870 it rose to 28·3 ; the deaths were 864,320 in 1869, 1,046,909 in 1870. In 1869 the death-rate of Prussia was 27·7 ; in 1870 it rose to 28·6, and in 1871 to 30·0, the deaths being 674,943, 703,659, and 770,079 respectively. Quetelet observes that in war two elements are at work in inflicting injury on a country as regards its population—first, the increased mortality amongst the adult male population ; secondly, the lessened birth and marriage rates.

(C.) *Pestilence.*—Recent examples are to be found in the history of the famine-fever in Ireland, and of the epidemic of cholera in 1865–66.

Up to the end of 1845 the Census Commissioners give the annual average number of deaths from fever in Ireland as 7,249. In 1846 the number increased to 17,145, and in 1847 to 57,095. In 1848 there were 45,948 fever-deaths ; in 1849, 39,316 ; in 1850, 23,545. Cholera helped to raise the mortality in Austria and Prussia during 1866, and in France the epidemic of 1865-66 caused an increase of the death-rate from 22·8 (1864) to 24·3 (1865) and 23·3 (1866).—*M. Legoyt.*

The law applies equally to cities. Thus, under the influence of an epidemic of cholera, the death-rate within the municipal boundary of Dublin rose from 27·8 in 1865 to 30·0 in 1866 ; and under the influence of the small-pox epidemic, six years later, it rose from 27·5 in 1871 to 30·8 in 1872.

(5.) *Influence of Seasons.*—" Over the years 1838 to 1871 inclusive the quarterly distribution of the deaths has been

such (in England) as to yield an annual average annual rate of 25·0 per 1,000 in the first, 22·1 in the second, 20·7 in the third, and 21·9 in the fourth quarter. In 1871 the rate was below the average in the March and June quarters, and above in the September and December quarters. Departures from the rule of the first (or winter) quarter being that of highest mortality, have occurred only three times—namely, in 1846, in 1849, and in 1868; the third (or summer) quarter has exhibited the lowest death-rate in every year save 1846, 1849, 1854, 1868, and 1870."[1] To the same effect Quetelet writes:—

"The rigors of winter are as a rule fatal to the human race. . . . The terms 'maximum' and 'minimum' do not show themselves at the same periods in all climates; but judging from the majority of the countries of Europe, the *maximum* of death occurs pretty regularly towards the end of winter, and the *minimum* towards the middle of summer."

The mortality, in fact, varies directly with the temperature of the air, extremes of either cold or heat being prejudicial to the public health.

In *The Times* of Friday, May 7, 1869, the Registrar-General of England wrote:—

"When the thermometer falls to the freezing point of water, the mortality is raised all over the country; and the population of London is excessively sensitive to cold; thus the corrected average deaths for the second week of January are 1,550, but the actual number of registered deaths this year (1864) was 2,427. The mean temperature of the preceding week, instead of 37·8°, had fallen to 26·7°; and the temperature of one chill night (Thursday, January 7) had descended to 14·3°, or to 17·7° below the freezing point of Fahrenheit, and 877 lives were extinguished by 'the cold wave of the atmosphere.'"

Excessive heat is almost as unhealthy as excessive cold. In the sentence quoted above from the Registrar-General's Thirty-fourth Report, the mortality is stated to have been

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[1] Registrar-General of England. *Thirty-fourth Annual Report for* 1871. P. 19.

high in the summer quarters of 1846, 1849, 1854, 1868, and 1870. The two years last named were characterised by extremely hot and dry summers. In Dublin, since 1864, the maximal mortality has invariably occurred in the first quarter of the year; while the minimal mortality has, with *one* exception, fallen in the third quarter. That exception was 1868, a year of warmth and drought, in the summer of which the fatality of diarrhœa became excessive. The following Table, compiled by Dr. Stark, is very instructive:—

TABLE VI.—*Showing the Effects of Cold and Heat on the Mortality in Scotland during the year 1868.*

Season	Average Mean Temperature of 10 years	Mean Temperature, 1868	Difference from Average Mean Temperature	Death-rate per cent. Average	Death-rate per cent. 1868	Lives saved	Lives lost
	°	°	°				
First quarter	37·9	40·6	+2·7	2·49	2·26	1,833	—
Second quarter	49·7	51·0	+1·3	2·22	2·12	796	—
Third quarter	55·3	57·4	+2·1	1·90	2·09	—	1,514
Fourth quarter	41·9	41·5	−0·4	2·14	2·22	—	673

The "very young, the weakly, and the aged" are especially susceptible to extremes of temperature. In 1867, 32·5 per cent. of all the deaths registered in Dublin were those of children under five years of age, and 19·5 per cent. were those of persons aged 60 and upwards.

The corresponding percentages for 1868 were 23·1 and 18·9 respectively. In the first quarter of 1867—*so noted for its intense cold*—the percentages were: of those under 5, 24·9; of those over 60, 23·5. In the third quarter of 1868—*the year of great heat*—the numbers were: of children under 5, 41·5; of adults over 60, 16·9 per cent.

Quetelet says:—"At no age is the influence of season on the mortality more marked than in advanced life, and at no age is it less marked than between 20 and 25 years, when the physical man, perfectly developed, is in the enjoyment of his full vigour."

He also points out that the influence of season is more pronounced

in country districts than in towns, where more resources for guarding against variations of temperature exist.

Two propositions may be laid down:—

(A.) *In* Summer *the tendency to sickness and death is chiefly connected with the digestive organs, diarrhœa and dysentery being the affections which are especially prevalent and fatal during this season. In* Winter *a similar tendency is noticeable in connexion with the organs of respiration; bronchitis, pneumonia, and pleuritis being the affections which are principally met with at this season.*

(B.) *In* Summer *a rise of mean temperature above the average increases the number of cases of, and the mortality from, abdominal affections. In* Winter *a fall of mean temperature below the average increases the sickness and mortality from thoracic affections.*

The influence of season on zymotic diseases may be most fitly considered in a subsequent chapter.

(6.) *Influence of Hours of the Day.*—The statistics on this point show some rather contradictory results. At the Hôpital de Saint Pierre, at Brussels, in 30 years, 1,397 deaths occurred from midnight to 6 a.m.; 1,321 from 6 a.m. to noon; 1,458 from noon to 6 p.m.; 1,074 from 6 p.m. to midnight. Dr. Buek, of Hamburgh, gives results which are at variance with these figures, for from his statistics the greatest mortality lies in the six hours from midnight to 6 a.m.

Dr. James Finlayson, of Glasgow, gives, in a recent paper,[1] the results arrived at by Mr. West Watson, the City Chamberlain of Glasgow, who tabulated the whole deaths (13,854 in number) which occurred in that city during 1865; and those arrived at by Dr. Schneider, of Berlin, who investigated the time of the occurrence of 57,984 deaths in the Prussian Capital. The results are embodied in this statement:—

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[1] *On the Hours of Maximum Mortality in Acute and Chronic Diseases. Glasgow Med. Journ.* April, 1874.

		Proportion of Deaths per 1,000.					
		A.M.		NOON		P.M.	
		12–4	4–8	8–12	12–4	4–8	8–12
Watson,	13,854 Deaths, -	159	**180**	174	162	166	159
Schneider,	57,984 Deaths, -	169	**191**	169	152	163	157

Dr. Finlayson has also compiled a Table, which contains nearly all the statistics on the subject, and is, therefore, worth reproducing here.

TABLE VII.—*Hours of General Mortality.*

	Total Observations	Proportion per 1,000			
		A.M. 12–6	NOON 6–12	12–6	P.M. 6–12
Virey: quoted from Oesterlen,	304	237	273	250	240
Buek: quoted from Oesterlen,	1,958	306	242	211	241
Berlinski and Casper, - -	5,591	252	291	243	214
Schneider, - - -	114,183	268	261	233	238
Steele, - - -	2,452	268	223	285	224
Smoler, - - -	1,000	334	276	189	201
Watson, - - -	13,854	250	264	246	240
Quetelet, - - -	5,250	266	252	278	204

"Hence," observes the same author, in another valuable paper,[1] "we may either say that the period of minimum vital energy, which exists during the first few hours after midnight, being deepened and perhaps prolonged, coincides with the summit of the death curve; or, phrasing it otherwise, that the time having arrived for a fresh rallying of the vital energies for a new day, the dying are found to be unable to respond to the call, and so they perish in greatest numbers at the very hours in which the living are manifesting, in every way, a renewed vigour."

(7.) *Influence of Professions, Mode of bringing up, etc.*—Quetelet observes:—

[1] *On some Indications of a Daily Periodicity in the Vital Functions of Man. Proc. Glasgow Philosoph. Soc.* 1873-74.

"It would appear that the condition most favourable to man is that of a regular life, producing what is sufficient for his wants, without being excited by passions or by the turmoil of cities. In agricultural pursuits man usually finds an easy-going life; he does not undergo, as in manufacturing districts, alternations of superabundance and of necessity; he is less acquainted with these two extremes, which inflict privations upon him or drive him to excesses."

On the whole, agriculturists are longer-lived than citizens, the rich than the poor, and the free than the enslaved. Dr. Farr has investigated the influence of occupation on the mortality of males aged 20 and upwards, in England. In 1851 the general annual rate of mortality of 1,000 males at or above 20 years of age was 20; that of farmers was 28; shoemakers, 18; weavers, 17; grocers, 11; blacksmiths, 18; carpenters, 19; tailors, 19; labourers, 21; miners, 15; bakers, 17; butchers, 21; innkeepers, 30. Judging from the ages at death, the farmers were the longest livers; labourers had a general mortality nearly equal to that of the population at large; and butchers and innkeepers were subject to a very great mortality. Intemperance in food and drink, and slaughter-house effluvia, are the most probable causes of the diminished viability amongst members of these callings. The average annual death-rate of soldiers on home service is—8·33 per 1,000 in the Royal Artillery; 6·56 in the Royal Engineers; 8·15 in the Household Cavalry; 7·07 in the Dragoon Guards; 7·78 in the Infantry of the Line; and 7·84 in the Foot Guards.[1]

Social position has a pronounced effect on longevity. The "Upper Class Life-Tables," compiled by Mr. Ansell, junr.,[2] and constructed upon the observed facts relating to 48,040 children of clergymen, legal practitioners, medical men, members of the aristocracy, bankers, merchants, &c., show that of 100,000 children born among the affluent, 8,045 die

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[1] *Army Med. Dep. Report*, 1874. Vol. xiv. P. 13.
[2] *Statistics of Families in the Upper and Professional Classes.* London. 1874.

in the first year of life; 4,684, from 1 to 5 years of age; 6,547, between 5 and 20 years. According to the English Life-Tables, the deaths per 100,000 among the general population are, at the above periods of life, 14,949, 11,369, and 7,407, respectively. The average annual rate of mortality among those under 60 years of age is 17·65 per 1,000, according to the English Life-Tables, but only 10·46 per 1,000, according to the Upper Class Life-Tables. This immense saving of life is due to the superior conditions under which the upper classes live.

Dr. William A. Guy, in a paper on the "Duration of Life in the Members of the several Professions,"[1] gives the average age at death of persons who have survived their 52nd birthday as follows:—"Males generally (England), 75·64 years; Clergy, 74·04; Gentry, 74·00; Medical Men, 72·95; Lawyers, 72·78; Navy, 72·62; Trade and Commerce, 72·32; Literature and Science, 72·10; Aristocracy, 71·69; Army, 71·58; Literature and Science (Foreign), 71·44; Fine Arts, &c., 71·15; Painters, 70·96; Chemists, 69·51; English Literature (Chambers'), 69·14; Members of Royal Houses, (Males), 68·54; Kings of England, 64·12."

Casper, of Berlin, has drawn up the following list, illustrative of the relative longevity of persons of various callings:—

Of 100	theologians, there attain the age of 70			42
„	agriculturists,	„	„	40
„	higher officials,	„	„	35
„	commercial men,	„	„	35
„	military men,	„	„	32
„	subordinate officials,	„	„	32
„	lawyers,	„	„	29
„	artists,	„	„	28
„	professors, etc.,	„	„	27
„	medical men,	„	„	24

From this list it would seem that mental labour is more

[1] *Journal of the Statist. Soc. Lond.* Vol. ix. P. 346.

injurious to man than bodily labour, and that both combined are most prejudicial. A quiet life, not exposed to excess of any kind, is most favourable to life.

The violence of human passions is shown to have a marked influence in cutting short life. In the section of this chapter on the "Influence of Age," we have already pointed out this fact. In Mr. Neison's work on "Vital Statistics" (London, 1853), the effect of *intemperance* on the probable duration of life is exhibited in this Table.

TABLE VIII.

Equation of Life, being the period of years of which there is an equal chance of living, among the General Population of England and Wales, and among the Intemperate.

Ages	General Population	Persons of Intemperate Habits	
20	44·212	15·557, being 35 per cent.	of the duration of life in the general population.
30	36·482	13·800 „ 38 „	
40	28·790	11·627 „ 40 „	
50	21·255	10·860 „ 51 „	
60	14·285	8·947 „ 63 „	

In epidemics the intemperate die rapidly; and Quetelet alludes to the effect of fear in inducing disease, and of the greater mortality of illegitimate children (see page 94) as further instances of the effect of morality.

(8.) *Influence of Civilisation and of Political and Religious Institutions.*—"Civilisation," says Quetelet, "in rendering the existence of man pleasanter, has also lengthened its duration; the development of science has tended to make isolated dwellings and enclosed towns salubrious, to effect the gradual disappearance of marshy localities, and of the so frequent causes of the epidemics which decimated our ancestors. By multiplying commercial relations between peoples, civilisation has also rendered famines less frequent and less for-

midable—the chances of such visitations being lessened, on the other hand, by agricultural improvements and by varying the means of subsistence. Medical Skill and Public Hygiene have equally discovered valuable means of combating mortality, whilst the development of industrial pursuits, and the guarantees afforded to society by more liberal institutions, have lent their aid to diffuse prosperity, and the most active means of preservation." The Registrar-General of England[1] says:—"Without affirming, on physiological grounds, that man was created to live a destined number of years, or to go through a series of changes which are only completed in 80, 90, or 100 years, experience furnishes us with a standard which can only be said to be too high. 17 in 1,000 is supplied as a standard by experience. Here we stand upon the actual. Any deaths in a people exceeding 17 in 1,000 annually are unnatural deaths. If the people were shot, drowned, burnt, poisoned by strychnine, their deaths would not be more unnatural than the deaths wrought clandestinely by disease, in excess of the quota of natural deaths; that is, in excess of *seventeen* deaths in 1,000 living."

As an instance of the saving of life which has been caused by the progress of civilisation and of hygiene, we may mention London, the annual mortality of which two centuries ago was 50 per 1,000, its inhabitants living only 20 years on an average. The yearly death-rate was:—1660–79, 80·0; 1681–90, 42·1; 1746–55, 35·5; 1846–55, 24·9; 1871, 22·6. The annual death-rate is now only 24 per 1,000, and the mean duration of life 42 years. Even within the past few years a great decline has taken place in the death-rate of many places in England which have had the benefit of sanitary improvements. Dr. Buchanan embodies the facts in a Table, an abstract of which is appended.

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[1] Report for Quarter ended December, 1857.

TABLE IX.—*Illustrating the Improvements of Public Health resulting from proper Works of Drainage and Water Supply.*

Population in 1861	Name of Town and Order of Population	Periods for which comparisons were made		General Death Rate		Deaths per 10,000 for each period compared								
						Enteric Fever		Diarrhœa		Cholera in each of Three Epidemics			Phthisis	
		Before Works	After Works	Before	After	Before Works	After Works	Before Works	After Works	1848–9	1854	1866	Before Works	After Works
160,714	Bristol .	1847–50	1862–5	245·5	242	10	6·5	10·5	9·5	82	11	1·5	31	25·5
68,056	Leicester .	1845-51	1862–4	264	252	14·6	7·7	16	19·3	1	10	—	43·3	29·25
52,778	Merthyr .	1845-55	1862–5	332	262	21·3	8·6	11·5	6·2	267	84	20	38·7	34·3
39,693	Cheltenham	1845–57	1860-5	194	185	8	4·7	8·3	7	—	—	—	28·75	21·25
32,954	Cardiff .	1847–54	1859-66	332	226	17·5	10·5	17·2	4·5	208	66	15·5	34·75	28·7
30,229	Croydon .	1845–50	1857-64	237	190	15	5·5	10	7	27	21	2	—	—
29,417	Carlisle .	1845–53	1858-64	284	261	10	9·7	11·3	12·5	22	6	—	32	35·4
27,475	Macclesfield	1845–52	1857–64	298	237	14·2	8·5	11·3	11	9	1	—	51·5	35·6
24,756	Newport .	1845-49	1860–65	318	216·5	16·3	10·3	11	6·5	112	1·5	12	37	25
23,108	Dover .	1843–53	1857-65	225·5	209	14	9	9·5	7	40	10	4·7	26·5	21·25

CHAPTER VIII.

Population.

Definition of Population.—Specific Population—Absolute Population.—Increase of Population dependent on Excess of Births over Deaths, and on Immigration.—Law of increase of Population.—Checks to its Increase.—Formula.—Density of Population.—Effective Population.—"Stationary" Population.—Census of United Kingdom in 1871.—Results relating to England and Wales, Scotland, and Ireland.

In the preceding chapters we have considered the statistical inquiries connected with the birth and death of man. It now becomes necessary to investigate the bearing of these inquiries on the body politic of mankind—in other words, to consider the laws of population.

The population, or the number of inhabitants of a country, district, or town, may be expressed in two ways: first, as the numerical total of the individuals; secondly, as the number of inhabitants to each unit of area, such as an acre, a square mile, etc. The latter is the *specific* population (Quetelet), a far more important datum in questions of political economy or of hygiene than the mere *absolute* population. With regard to political economy, Quetelet remarks that if all physical conditions were the same in the different countries of Europe, there would be no better gauge of the productive and industrial powers of a country than the density of its population. With regard to hygiene, it will be shown in a subsequent chapter how intimate are the relations between public health and density of population.

Increase of population depends on an excess of births over deaths, and on immigration. It is more or less rapid according to the prosperity of, and the facility of obtaining the means of subsistence amongst, a community. Towards

the close of the last century Malthus laid down the proposition that *population, when unchecked, goes on doubling itself every* 25 *years, or tends to increase in a geometrical ratio*—that is to say, the human race may, under the most favourable circumstances, increase in a ratio corresponding to the series of numbers 1, 2, 4, 8, 16, 32, 64, etc. The truth of this proposition is accepted by the foremost statisticians of later years. Malthus also arrived at the conclusion that the increase of food, depending on the fertility of land, its reclamation, and improvements in agriculture, advanced only in an arithmetical progression, or in a ratio corresponding to the series of numbers 1, 2, 3, 4, 5, 6, etc. This proposition has proved to be as well founded as the former. But Malthus, in venturing to theorise on the appalling results which would follow the action of these laws, overlooked the element of *free trade*, which enabled a nation to draw upon the fertility of the world at large for the sustenance of its own increasing population. In consequence of this, the true philanthropy of the man was lost sight of, and he was most undeservedly looked upon as the enemy of the poorer classes.

The checks to the increase of any population may be ranged under two heads—*preventive* (*l'obstacle privitif*—Quetelet) and *positive* ((*l'obstacle destructif*—Quetelet). When an increasing population has reached the limit of its means of subsistence, the former check should come into play through the reason and foresight of the individual members of the population. This *moral restraint* is the prudential withholding from marriage, with a conduct strictly moral during the continuance of the restraint. It may be practised for a limited period or throughout life. The positive check to increase of population is expressed by the words *vice* and *misery*. A writer in the *Penny Cyclopædia*[1] well sums up the factors included under these terms:—*Vice*, promiscuous sexual intercourse, unnatural passions, violation of the

[1] Article : *Population*. Vol. xviii. P. 408.

marriage-bed, improper arts to conceal the consequences of irregular connexions; *Misery*, unwholesome occupations, severe labour, exposure to the seasons, extreme poverty, bad nursing of children, excesses of all kinds, the whole train of common diseases and epidemics, wars, plagues, and famines.

Owing to the operation of all these checks in a varying degree, the population of a country is seldom seen increasing in a geometrical progression. The United States show an increase of population from 1780 to 1825 which is only in arithmetical progression. This is exhibited in a table given by Quetelet:—

TABLE X.

Year	Population	Annual increase per cent.
1780	2,051,000	6·2
1790	3,929,326	3·0
1800	5,306,035	3·1
1810	7,239,703	2·9
1820	9,654,415	1·9
1825	10,438,000	—

In this case the annual increase may be regarded as 190,822. Representing this difference by d, the population in 1780 by P, and a number of years by x, the population of the x^{th} year is found by the equation:—

$$Px = P + dx.$$

This formula may be employed for estimating the rate of increase of population in any place or country. But it must be remembered that the annual increase of population of a country is an inaccurate basis on which to ground a calcucation as to the period within which that population will double itself.

An amusing example of the fallacies likely to arise from adopting, for

an indefinite period, a fixed doubling period, is to be met with in a book, written nearly 200 years ago, by Sir William Petty. This author estimated the population of London in 1683 at 670,000, the doubling period at 40 years, and the population of England in the same year at 7,400,000, and its doubling period at 360 years. Going upon these data, he calculated that the population of London in 1800 would number 5,359,000 souls, and (at the same rate of progression) 10,718,880 in 1840, in which year the population of the whole country, *including* London, would be 10,917,389, or only 200,000 people to constitute the entire rural population of England!

"If a country," says Quetelet, "by virtue of increasing civilisation, takes a fresh impulse, and by the development of its products extends the limits within which its population may augment, under the most favourable circumstances, it is by a geometrical progression that it will tend to reach those limits." He adds:—"The most favourably situated countries seldom present the phenomenon of a population increasing according to a geometrical progression. England, however, affords us a striking example, and one well worth attention. After being stationary, and even retrograde, at the beginning of the last century, her population commenced to increase successively with various oscillations until towards the middle of that century, when—receiving a second impulse—it began to advance in arithmetical progression. A fresh and still more energetic impulse influenced it at the beginning of the present century, since when it has continued to develop according to geometrical progression." The obstacles to the increase of population in England are shown by Quetelet to have been diminishing "in consequence of the vast strides in her industries, and the introduction of machine-power, the products of which represent a population which England was far from possessing." This estimate of Quetelet as to the rate of increase of the population of England will be further illustrated in the concluding paragraphs of this chapter, in which the principal facts connected with the Census of 1871 will be given for the United Kingdom and its three divisions.

The *Specific Population* varies much in different countries. Recent enumerations of the number of inhabitants in the principal countries of Europe show the number of persons to one square mile, in the different European States, to be as follows, viz.:—Belgium, 445; Holland, 309; United Kingdom, 259; Italy, 243; Germany, 196; France, 178; Switzerland, 169; Austria, 149; Denmark, 127; Portugal, 115; Spain, 85; Greece, 72; Turkey, 55; Russia, 35; Sweden and Norway, 20.

Belgium, Holland, the United Kingdom, and Italy are, therefore, the most densely populated countries of Europe—Turkey, Russia, and Sweden and Norway the least so. Quetelet reminds us that, in order to render tables of population comparable with each other, they must be individually multiplied by a *constant coefficient*, representing the value of what is necessary to an individual of each nation as subservient to his wants. Regard being had to this constant coefficient, the specific population of a country is the measure of its degree of prosperity, for it cannot with impunity increase beyond the means of subsistence provided by that prosperity—if it does, a high mortality is the inevitable consequence.

The specific population of a city or town is more commonly known and described as the *density of the population.* In the United Kingdom, the standard of city populations is so many persons per acre. It is most important that the density should be accurately determined in each town, as the rate of mortality is largely influenced by it. A reference to Table IV., p. 104, will prove the truth of this statement. In 1874 the density of the population, or number of persons to an acre, in the chief towns in the United Kingdom was:—London, 45·1; Portsmouth, 26·8; Norwich, 11·0; Bristol, 43·3; Wolverhampton, 20·9; Birmingham, 43·0; Leicester, 33·2; Nottingham, 45·5; Liverpool, 98·0; Manchester, 82·8; Salford, 25·7; Oldham, 18·5; Bradford, 22·6; Leeds, 12·9; Sheffield, 13·3; Hull, 36·0; Sunderland, 31·6; Newcastle-on-Tyne, 25·2; Edinburgh, 47·8; Glasgow, 100·4; Dublin, 31·3;—the mean of these 21 towns being 36·6. The density of the population, according to the census of 1871, in the registration districts of the chief Irish towns was:—Dublin, 31·3; Belfast, 8·8; Cork, 6·6; Limerick, 5·2; Londonderry, 1·4; Waterford, 1·2; Galway, 0·9; and Sligo, 0·6.

Within the municipal boundary of Dublin the density is 65·7. It will be noticed that the densities for the Irish town districts are very much less than those of the English and Scotch towns. Some of them are, in

fact, little more than the densities of rural districts. It is very significant that, notwithstanding this, the rate of mortality in the Irish town districts too often exceeds that of the large towns of England and Scotland.

The study of the *Effective Population* of different countries has lately been undertaken by an American medical writer, Dr. Edward Jarvis, of Dorchester,[1] U.S. The effective population is that portion of the community which is aged between twenty and seventy years. Within this period of 50 years man is able to provide for his own wants, and also to support the rising generation up to 20. From 20 to 70 years, therefore, may be called the sustaining period of life; from birth to 20 years, the dependent period. The effective power of a nation consists in the number of its people within the sustaining period, and in the proportion these bear to the dependent classes. In an article upon the work in question, the editor of the *Pall Mall Gazette* points out that the author's tables represent the potential rather than the active effective populations of the various countries—no allowance being made in them for the number of persons productively employed before 20 years of age, for the enormous standing army of France, or for the pauper horde of England. With respect to effective population France ranks first, Switzerland second, Belgium third, Prussia eighth, England ninth, and Ireland last. The proportion of the effective class in France exceeds that in Ireland by 35 per cent, the difference being due on the one hand to the stationary nature of the population in France, and on the other to emigration, early marriages, and large families in Ireland.

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[1] *Political Economy of Health. Fifth Annual Report of the State Board of Health, Massachusetts.* 1874. P. 333.

TABLE XI.—*Proportions of the Sustaining and Dependent Classes.*

Nation or State	Year	Sustaining—20 to 70	Dependent			Number dependent for 1000 sustaining
			Under 20	Over 70	Totals	
France	1866	60·32	36·09	3·64	39·68	657
Massachusetts (white) .	1870	56·80	40·30	2·80	43·10	759
Switzerland . . .	1861	56·20	41·22	2·58	43·80	779
Belgium . . .	1856	54·61	42·51	2·88	45·39	831
Sweden . . .	1860	54·51	42·67	2·82	45·49	834
Denmark . . .	1860	54·30	42·76	2·94	45·70	845
Spain	1858	53·46	44·66	1·48	46·14	863
Holland . . .	1859	53·52	44·15	2·33	46·48	868
Prussia . . .	1869	52·62	45·34	2·03	47·37	880
Vermont . . .	1870	53·30	42·50	4·50	47·00	900
England . . .	1861	52·21	45·04	2·74	47·78	915
Scotland . . .	1851	51·30	45·60	2·95	48·55	946
Norway . . .	1865	50·78	45·44	3·77	49·21	969
United States (white) .	1870	49·04	49·18	1·80	50·98	1,039
South Carolina (white) .	1870	46·70	51·20	1·90	53·10	1,136
North Carolina (white) .	1870	46·04	51·70	2·06	53·96	1,153
Ireland . . .	1841	46·50	52·03	1·48	53·51	1,201
United States (coloured)	1870	44·80	53·60	1·50	55·10	1,229
Georgia (white) . .	1870	44·40	53.90	1·50	55·40	1,248

The average duration of effectiveness enjoyed by the people between 20 and 70 years of age, was: in Norway, 39·61 years; Sweden, 38·10; United States (males), 37·46; Hanover,

35·81; England, 35·55; France, 32·84; and Ireland (in 1841), 28·88. For every 1,000 years expended in the developing period upon all that are born, including both those who die in, and those who survive, the period from birth to 20 years, the labouring and productive years are:—in Norway, 1,881 years; Sweden, 1,749; England, 1,688; Hanover, 1,686; United States (males), 1,664; France (1806), 1,398; and Ireland (1841), 1,148.

A population is said to be *stationary* when the yearly number of deaths exactly equals the yearly number of births and there is no disturbing migration inwards or outwards. Under these circumstances, as we have seen, an enumeration of the deaths at each age, made at any given period, affords data for a reliable Life-Table.

The census of 1871 has placed us in possession of very accurate data with regard to the increase of population in the United Kingdom. It will be convenient to give the leading facts connected with the estimated and enumerated populations in this place. The enumerated population in 1871 was:—

United Kingdom	31,628,338
England	21,495,131
Wales	1,217,135
Scotland	3,360,018
Ireland	5,411,416
Isle of Man and Channel Islands . . .	144,638

United Kingdom.—On the night of Sunday, April 2, 1871, the gross population of the United Kingdom, including the islands in the British Seas and the army, navy, and merchant seamen abroad, was 31,857,338 persons; excluding the last-named classes, it was 31,628,338; and excluding both the islands and the seamen of all descriptions serving abroad, it was 31,483,700.

The comparison between the estimated and the enumerated population is exhibited in the following statement, which

deals only with the United Kingdom proper—England and Wales, Scotland and Ireland :—

	United Kingdom.	England and Wales.	Scotland.	Ireland.
Registered Births, 1861–70 - -	10,084,249	7,500,096	1,121,321	1,462,832
Registered Deaths, 1861–70 -	6,413,890	4,794,498	705,530	913,862
Excess of Births, or Natural Increase, 1861–70	3,670,359	2,705,598	415,791	548,970
Emigration, 1861–70 - - - -	1,674,594	649,742	158,226	866,626
Natural Increase *less* Emigration	1,995,765	2,055,856	257,565	—317,656
Enumerated Population, 1861 -	28,927,485	20,066,224	3,062,294	5,798,967
Population in 1871, as estimated upon the basis of Natural Increase *less* Emigration	30,923,250	22,122,080	3,319,859	5,481,311
Enumerated Population, 1871 -	31,483,700	22,712,266	3,360,018	5,411,416
Excess or Defect in Enumerated as compared with Estimated Population of 1871	+ 560,450	+ 590,186	+ 40,159	— 69,895

Mr. James Lewis,[1] to whom we are indebted for the foregoing statement, writes as follows :—

"The present population of the kingdom (*exclusive* of the army, navy, and merchant seamen abroad) represents an increase since 1861 of 2,557,406 persons, which is equivalent to a rate of 8·8 per cent. in the ten years, and to a daily addition of 700 to the population.

"During the last decade England has added 2,646,042, or 13 per cent., to her population, and Scotland 297,724, or 9·7 per cent.; while Ireland counts 387,551, or 6·7 per cent., fewer inhabitants than she had in 1861. Had the circumstances of Ireland during the last ten years not differed from those of Great Britain, the population of the United Kingdom would now be about a million greater than it is. The Irish Census Commissioners speak of the period between 1861 and 1871 as one in which 'the country was remarkably free from any outbreak of pestilence, scarcity of food, or of the other social calamities which have occasionally retarded the growth of the population.' The decrease of population is accounted for by the very great emigration which has taken place, the emigrants of Irish origin having numbered 866,626 in the ten years. The causes of the continued decline of the Irish population are a profoundly interesting study, which will, no doubt, receive an impetus from the facts revealed by the Census : from 1801 to 1845 there was an unbroken chain of increase, while from that date to this the process of diminution has proceeded with equally unswerving steps."

[1] *Digest of the English Census of 1871.* London : Edward Stanford. 1873.

England and Wales.—By the census of 1871, the population of England was ascertained to be 21,495,131; that of Wales to be 1,217,135. According to the same authority, the estimated population of England and Wales was 5,466,572 in 1651, and 6,335,840 in 1751, the increase in 100 years being, therefore, only 869,268. In the next 100 years, however, the increase was nearly 12,000,000, as shown in this Table:—

TABLE XII.

Year	Population	Increase between each Census	Decennial Rate of Increase per cent.	Decenniads
1801	8,892,536	...	...	...
1811	10,164,256	1,271,720	14·30	1801–11
1821	12,000,236	1,835,980	18·06	1811–21
1831	13,896,797	1,896,561	15·80	1821–31
1841	15,914,148	2,017,351	14·52	1831–41
1851	17,927,609	2,013,461	12·65	1841–51
1861	20,066,224	2,138,615	11·93	1851–61
1871	22,712,266	2,646,042	13·19	1861–71

"The closing years of the great French war and the early years of the long peace which succeeded were marked by a proportionately much more rapid growth of the population than any which has since been observed. Between 1821 and 1861 the increase went on, but the rate of increase was a decreasing one. Now, from whatever cause, not only have we an actual increase of numbers, but also an increase in the rate. It is probable that the disturbed state of affairs upon the Continent prior to, and at the time of the last Census, may have led to an unusually large influx of foreigners; and ultimately, when the various nationalities of the enumerated population have been ascertained, an estimate may be formed of the extent to which the exceptional increase above noted is due to circumstances of merely temporary operation. Defects in the registration of births and deaths and in the records of emigration, as well as the absence of any account of immigration, combine to baffle attempts to trace out the degree in which the growth of the population is dependent upon any one cause at a given period. Take, for example,

what may be called the *natural increase*, resulting from the excess of births over deaths. This excess amounted to 4,966,533 in the twenty years, 1851-70 ; and the addition of this number to the enumerated population in 1851 would give 22,894,142 as our present population, supposing neither emigration nor immigration had disturbed our natural growth. From the returns of the Emigration Commissioners, it appears that 1,290,058 persons of English origin emigrated during the twenty years, and thus our gain by excess of births is at once reduced to 3,676,475, which would give us a present population of 21,604,084, or less by 1,108,182 than the census shows we have. How this influx of 1,108,182 has arisen—how far it has been caused by births which have escaped registration, by the advent of foreigners, by the return of the emigrants of former years, and by the tendency of Irishmen and Scotchmen to settle in England—it is impossible, in the present state of our national statistics, to say. It is for the political economists who lament the increase of population, and who inculcate the necessity of adopting certain "checks" upon its further development, to explain how they would "check" this flood of immigration which helps so much to swell the numbers of our people. It seems hard, to say the least, that the natural home-supply should be checked while the foreign supply is permitted to go on at its pleasure."

"The annual rate of increase in the 70 years of this century was 1·35 per cent., the actual aggregate increase being 13,819,730, or 1·55 per cent. The population of 1801 doubled its numbers in 1851 ; at the rate of increase prevailing in the last ten years, the population would double itself in 56 years, while the period of doubling deduced from the annual rates reigning during this century is 52 years."

Of the total population, 11,058,934 were males, and 11,653,332 were females, an excess of 594,308 in favour of the latter.

Scotland.—The population by the census of 1871 was 3,360,018, including 1,603,143 males, and 1,756,875 females.

Ireland.—The population in 1871 was 5,402,729, being 396,208 less than the population in April, 1861. The sexes were 2,634,123 males and 2,768,636 females. In the ten years, 1861–1871, the population of Ireland decreased to the amount of 6·83 per cent. ; from 1851 to 1861, the decrease was 11·79 per cent. ; and from 1841 to 1851, it was 19·79 per cent., or very nearly *one-fifth.* These facts are embodied in the following Tables.

Table XIII.

Provinces	Population 1841	1851	1861	1871
Leinster, - -	1,982,169	1,682,320	1,457,635	1,335,966
Munster, - -	2,404,460	1,865,600	1,513,558	1,390,402
Ulster, - - -	2,389,263	2,013,879	1,914,236	1,830,398
Connaught, - -	1,420,705	1,012,479	913,135	845,993
Total, - -	8,196,597	6,574,278	5,798,967	5,402,759

Table XIV.

Provinces	Decrease 1841 to 1851		Decrease, 1851 to 1861		Decrease, 1861 to 1871	
	Persons	Rate per Cent.	Persons	Rate per Cent.	Persons	Rate per Cent.
Leinster, -	299,849	15·13	224,685	13·36	121,669	8·35
Munster, -	538,860	22·41	352,042	18·87	123,156	8·14
Ulster, -	375,384	15·71	99,643	4·95	83,838	4·38
Connaught,	408,226	28·73	99,344	9·81	67,142	7·35
Total, -	1,622,319	19·79	775,714	11·79	396,208	6·83

The chief cause of the decrease of population in this country has been, undoubtedly, emigration. In the decenniad ending 1861 no fewer than 1,227,710 Irish-born persons emigrated from Ireland, and in the decenniad ending March 31, 1871, 819,903 Irish-born persons emigrated from the United Kingdom. Taking the increase of population by excess of births over deaths at the rate of ·92 per cent. per annum, the population of Ireland in 1871 should have been about 6,297,275, had no disturbing cause intervened. The absence of any extensively prevailing and mortal pestilence, the comparative sufficiency of food, and the diminution in numbers of the pauper inhabitants of Workhouses, between 1851 and 1871, justify us in assigning emigration as the principal factor in determining the remarkable decrease in population already mentioned.

CHAPTER IX.

The Development of Man.

Development of the Physical Qualities of Man.—Height, Weight, Strength.—Lumbar Power.—Manual Power.

We can in this chapter consider only the *physical*, as distinguished from the intellectual, development of man, and that too but briefly.

Height.—Principal J. D. Forbes, from a series of experiments made on English, Scotch, and Irish students, gives the height in inches, including shoes, at different ages, as follows:—

Table XV.

Age	English	Scotch	Irish	Belgian (after Quetelet)
16	66·5	66·8	?	64·2
20	68·7	69·1	69·8	67·9
24	68·9	69·3	70·2	68·2

Taking the mean of the heights at 24 years of age, we find the average height of the adult man to be slightly over 5 feet 9 inches, namely 69·2 inches.

Quetelet's conclusions on this subject are these:—

I. The limits of growth in the two sexes are unequal, because—(1) The female is smaller at birth than the male; (2) her full development is sooner reached; and (3) her yearly growth is less than that of the male.

II. The height of dwellers in cities exceeds by 2 or 3

centimetres (about 1 inch) that of dwellers in the country, at the age of 19 years.

III. It would not appear that the growth of man is quite completed at the age of 25.

IV. The affluent generally exceed the mean height; misery and fatigue, on the contrary, would seem to be obstacles to development in height.

V. The growth of the child, from several months before birth to full development, follows a law of continuity such that the rate of growth diminishes successively according to age.

VI. Between the ages of 5 and 16 years, approximately, the *annual* rate of growth is tolerably regular, and is the twelfth of the rate of growth of the fœtus during the months prior to birth.

VII. Lastly, setting out from 50 years, both man and woman undergo a diminution in height, which becomes more and more marked, and may be estimated at about 6 or 7 centimetres ($2\frac{1}{2}$ to 3 inches) towards 80 years.

This diminution in height is well shown in a Table given by Quetelet:—

Age	Height of Men		Height of Women	
	Metres	Inches	Metres	Inches
40	1·684	66·3	1·579	62·2
50	1·674	66·0	1·536	60·5
60	1·639	64·6	1·516	59·7
70	1·623	63·9	1·514	59·6
80	1·613	63·6	1·506	59·3
90	1·613	63·6	1·505	59·3

At birth the height of a boy is ·496 metres or 19·5 inches; that of a girl ·483 metres, or 19·0 inches. When they have

reached their full development, the height of man and woman is about $3\frac{1}{4}$ times as great as it was at birth.

Weight.—From birth Quetelet shows that there is an inequality in weight as well as in height between children of the two sexes, and this inequality is in favour of males. In the Hospice de la Maternité de Bruxelles the average weight of males, at birth, was 3·20 kilogrammes, or 7·04 lbs.; that of females was 2·91 kilogrammes, or 6·40 lbs. The limits of weight, at birth, in the Lying-in Hospital, Brussels, were, for boys—maximum, 4·50 kilogrammes; minimum, 2·34 kilogrammes; for girls—maximum, 4·25 kilogrammes; minimum, 1·12 kilogrammes (1 kilogramme = 2·2 lbs). According to the *Dictionnaire des Sciences Médicales*, the average weight of a child, born at full term, and in good health, is 3·059 kilogrammes, or $6\frac{3}{4}$ lbs. The Brussels average is 3·055 kilogrammes, or 6·7 lbs., without regard to sex. The weight of a child diminishes during the first few days after birth—a point first dwelt upon by M. Chaussier—and does not sensibly increase until after the first week. A year after birth, children of both sexes have trebled their weight, and, immediately before puberty, the weight of both sexes is exactly half that subsequent to their full development respectively. Principal Forbes gives the weight, in pounds, of adults, including clothes, as follows:—

Age	English	Scotch	Irish	Belgian (Quetelet)
16	127	125·5	129	117·5
20	144	146·5	148	143·0
24	150	152·0	155	149·5

The average weight of the adult man, deduced from these values, is 151·6 lbs., or 10 stones 11·6 lbs.

At Cambridge 80 men, aged from 18 to 23 years, gave an average weight of 151 lbs.

Quetelet's conclusions as to weight are these:—

I. At equal ages man is generally heavier than woman. It is only at about the age of 12 that individuals of both sexes weigh the same. This is due to the rapid increase of weight at puberty, and to the earlier occurrence of this epoch in females.

II. Man attains his maximal weight towards 40 years of age, and begins to lose weight sensibly towards the age of 60. At 80 he has lost some 6 kilogrammes (about 13 lbs.) in weight.

III. Woman reaches the maximum of weight later than man—namely, towards the age of 50 years. During her reproductive period the increase of her weight is trifling.

IV. At the period of their full development both sexes weigh almost exactly 20 times as much as they do at birth, whilst their height is only $3\frac{1}{4}$ times as great.

V. In old age man and woman lose from 6 to 7 kilogrammes in weight.

VI. During the period of growth of individuals of both sexes, the squares of the weights at different ages may be regarded as proportional to the fifth powers of the heights.

VII. After the completion of growth in both sexes, the weights are almost as the squares of the heights.

Strength.—The development of strength has been investigated in both sexes by Quetelet by determining the lumbar power (*la force rénale*), or weight which could be carried on the back, and the power of the hands by means of Regnier's dynamometer. "According to Regnier," he says, "man is in the plenitude of his strength from 25 to 30 years, and can, by squeezing forcibly with both hands, make an effort equivalent to 50 kilogrammes, and raise a weight of 13 myriagrammes (1 myr. = 22 lbs.). Until about 50 years he preserves this degree of strength, which subsequently progressively diminishes. A woman's strength has been

estimated as equivalent to that of a young man aged from 15 to 16 years—that is, to two-thirds of that of an adult man of ordinary strength. The power of the right hand is commonly greater than that of the left hand, and the sum, as a rule, equals the power of the two hands acting together."

From Tables which he has compiled with infinite care and patience, Quetelet concludes that the *lumbar power* of females differs less from that of males during childhood and in adult life. During childhood the lumbar power of boys exceeds that of girls by about a third, towards puberty by one-half, and the power of adult man is double that of woman. The average strength of a well-developed man of 30 is 89 kilogrammes, or 19 kilogrammes more than his weight in his dress; so that such a man could hold on by the end of a rope with a weight of 19 kilogrammes attached to his body.

The *manual power* of man is, at different ages, greater than that of woman, the difference being generally less at early ages than in adult life. Before puberty the ratio is 3 to 2, and it afterwards becomes 9 to 5. The influence of occupation is very pronounced, workmen, masons, carpenters, etc., being especially powerful. In Quetelet's experience, contrary to Regnier's, the hands acting together produce a greater effect than the sum of the effects produced by them acting singly. He finds also that the right hand is one-sixth stronger than the left.

Principal Forbes gives the strength in pounds as follows:—

Age	English	Scotch	Irish	Belgian (Quetelet)
16	336	314	?	236
20	385	392	416	310
24	402	421	431	337

CHAPTER X.

Preventable and Controllable Diseases.

Prevention of Disease the sole object of Sanitary Legislation.—Classification of Preventable Disease.—Points of Consideration of Preventable Disease.

As the sole object of sanitary legislation and organisation is the prevention and control of disease, it is necessary in a work such as the present to devote special attention to diseases of a controllable nature, not only collectively, but individually. The diseases belonging to this class are of a very varied nature, and might be arranged under many heads. We can deal here only with those diseases which are now known to be capable of control by public measures of prevention. Although the list is not a long one, yet it includes a very large proportion of the diseases which make up the grand total in the bills of mortality, diminish the average duration of life, and lead to a general low state of national health. The majority of these diseases belong to the zymotic class, but in each class in the Registrar-General's tables is to be found some one (or more) controllable disease, for even over what are termed constitutional diseases a considerable amount of control may be acquired by continued enlightened hygienic action. The following list groups in a convenient form diseases belonging to the preventable and controllable class:—

I.—Zymotics:

- (*a.*) Continued fevers;
- (*b.*) Cholera and diarrhœa;
- (*c.*) Croup, diphtheria, and pythogenic pneumonia;
- (*d.*) Erysipelatous affections;
- (*e.*) Exanthemata;
- (*f.*) Intermittent fever.

II.—Diseases caused by insufficient or unwholesome food:

(*a.*) Dysentery;
(*b.*) Diarrhœa;
(*c.*) Purpura;
(*d.*) Scurvy;
(*e.*) Affections resulting from the use of putrid or diseased meat or fish.

III.—Diseases usually called constitutional, but which are caused or promoted by general unhealthy conditions, as

(*a.*) Scrofulous affections: phthisis, scrofula.

IV.—Diseases caused by unhealthy trades, as

(*a.*) Painters' colic and paralysis;
(*b.*) Miners' and knife-grinders' rot, etc.

V.—Diseases arising from vicious habits and immorality, as

(*a.*) Alcoholism;
(*b.*) Syphilis.

This last group scarcely comes within the control of the practical hygienist, though requiring his earnest attention.

We have endeavoured to arrange the above diseases according to their importance in relation to Preventive Medicine. We shall now consider each of these classes in its turn, and from the following points of view:—

1st. Damage inflicted by these diseases.
2nd. Their mode of origin and propagation.
3rd. Their prevention or control.

CHAPTER XI.

Zymotic Diseases.

Damage done by Zymotic Disease.—Relation of Zymotic Death-rate to General Death-rate.—Money Loss from Zymotic Disease.—Loss from Small-pox in Dublin.—Endemic Zymotics more Destructive than Epidemic Zymotics.—Conditions under which Zymotics spread.—Locality.—Drainage and Water Supply.—Age, Condition, and Construction of Houses.—Fever Nests.—Climate and Season.—Density of Population.—Pauperism.—Cleanliness.—Insanitary Conditions not only cause, but increase the Mortality from Zymotics.

The diseases usually called "zymotic" are by far the most important group of the preventable and controllable class. Not only do these diseases themselves directly contribute largely to the deaths recorded in the Registrar-General's returns, but indirectly they increase the mortality registered as arising from other causes. Undoubtedly a large number of tubercular, strumous, phthisical, and renal affections, have their origin in previous attacks of zymotic disease. Thus, enteric fever and scarlatina frequently lead to tubercle and scrofula, pneumonia to pulmonary consumption, scarlatina to renal disease, etc.

It is impossible to estimate exactly the proportion of deaths from secondary causes, originating in zymotic diseases, but even neglecting these, the amount of damage inflicted by them is immense. Thus from a Return ordered by the House of Commons, on the motion of Mr. W. H. Smith, M.P. for Westminster, we find that of the 3,249,077 deaths which occurred in the United Kingdom during the five years 1865 to 1869 inclusive, 712,277, or 21·9 per cent. were caused by zymotic diseases; in other words, about one in every five of the deaths is caused by a disease of this kind, and we lose at the rate of about 150,000 people annually in the United Kingdom from zymotic diseases. The deaths were distributed between the three countries in the following proportions:

England—111,418, being $\frac{1}{4}$ of the total mortality, or 1 in 190 of the population.

Scotland—16,193, being ¼ of the total mortality, or 1 in 194 of the population.

Ireland—18,416, being ⅕ of the total mortality, or 1 in 308 of the population.

The deaths in Ireland from the principal zymotics in the five years thus mentioned were—

Fever, - - -	21,895,	or at the rate of	4,379	per annum.
Scarlatina, - -	16,474.	„ „	3,295	„
Diarrhœa, - -	10,081,	„ „	2,016	„
Whooping-cough, -	9,475,	„ „	1,895	„
Small-pox, - -	1,553,	„ „	314	„

From this Table it appears that by far the most serious of these zymotics are such as are always amongst us—1st, Fevers; 2nd, Scarlatina. We shall presently show more fully that the constantly present zymotics are far more serious than those which only occasionally visit us, such as cholera and small-pox. While these latter quickly sweep away large numbers, thereby striking us with terror, the former gradually and silently kill thousands without much notice being taken of the effect produced by them.

We have shown what a large proportion of the death-rate is caused by zymotic diseases—namely, one-fourth in England and Scotland, and one-fifth in Ireland, or, more exactly, 21·9 per cent. of the total mortality of the United Kingdom. A large proportion of these deaths is concentrated in the large towns, and is the chief cause of the town death-rate being in excess of the country death-rate. From this we may conclude that the variations in death-rate in large towns will follow very closely the variations in prevalence of zymotic disease; and the relations in death-rate between different towns will also closely follow the relative prevalence of zymotic disease.

In the case of Dublin, for example, with few exceptions, the variations in the zymotic deaths correspond very closely with the variations in total deaths. The chief exceptions may be easily explained, as they depend upon the effect of cold, especially intense cold, in augmenting the deaths from chest diseases to an enormous extent. Again, if we arrange

the following large towns according to their death-rate, placing the one with the lowest death-rate at the top of the list, and in a parallel column arrange the same towns according to the death-rate from zymotic diseases, we shall find a close correspondence:—

TOTAL DEATH-RATE.	ZYMOTIC DEATH-RATE.
1. Birmingham,	1. Bristol,
2. Hull,	2. Hull,
3. London, Bristol,	3. Birmingham, Leeds,
4. Dublin,	4. Edinburgh,
5. Sheffield,	5. London,
6. Edinburgh,	6. Dublin,
7. Leeds,	7. Sheffield,
8. Newcastle-on-Tyne,	8. Liverpool,
9. Salford,	9. Manchester and Newcastle,
10. Manchester,	10. Glasgow,
11. Liverpool, Glasgow.	11. Salford.

Hull is the only instance where this correspondence is exact, as it stands second on both lists. Although Bristol stands highest as being most free from zymotics, yet it is third on the death-rate list; Birmingham being first on this list, and third on the zymotic list. The cases of Birmingham and Bristol we shall refer to again.

A reference to Table IV. (see page 104) also shows a marked parallelism between the zymotic and total death-rates ; Bristol being a well-marked exception, an exception which is to be altogether attributed to the extensive measures undertaken to improve the sanitary condition of that city.

The proposition that the zymotic death-rate has a nearly constant relation to the total death-rate is also shown by a comparison of the 28 districts of the London Registration Division for the year 1870, as shown in Table V. (see page 105) constructed on the same principle as that for the 13 large towns mentioned above.

From an analysis of the Tables referred to, we find that of the 13 large towns enumerated, the death-rate is above average in 8 ; that the zymotic death-rate is above average in 5, nearly at average in 1, below average in 2 of these 8 towns ; and that of the towns where the death-rate is below average, the zymotic death-rate is never above average, and nearly up to average in but one case only.

Besides the absolute loss of life, the money loss is immense to the community and to individuals. Thus the outbreak of small-pox, the most severe epidemic that has visited Dublin this century, except the great fever of 1826, the famine fever of 1847, and the cholera epidemics of 1832 and 1849, cost Dublin not less than £35,000, probably £40,000, for the treatment of the sick. Nearly the whole of this was spent on hospital appliances, food, medicine, and stimulants for the sick, the medical attendance costing a mere trifle, probably not £1,000 for poor law medical relief. Besides this, there was great loss to the trade of the city. The records of the Mansion House Small-pox Relief Committee show the incalculable amount of misery caused by epidemics. They show that the applicants for relief represented 6,000 persons who were affected by small-pox, and who were reduced to apply for relief on account of the loss caused by the disease to them and their friends ; 667 heads of families suffered, 179 heads of families died, thus more or less permanently pauperising those who were dependent upon them for support.

Small-pox and cholera, however, do not hold the first place as regards destructiveness amongst zymotics when a long series of years is considered. Epidemics of these two diseases are indeed more sharp and decisive, but other members of the class, such as fever, scarlatina, measles, and diarrhœa, do their work of destruction quite as surely, and with even greater persistence, creating alarm only when they arise as epidemics.

This is a matter which Medical Officers of Health should specially impress upon local authorities and the public, as it is generally lost sight of in sanitary operations. Let us compare the amount of damage done by these various zymotics in Dublin and in Ireland for a period of ten years, from 1864 to 1873 inclusive.

TABLE XVI.—*Showing the Total Deaths, and Annual Average Number of Deaths from Seven principal Zymotics, in the Dublin Registration District, for* 10 *years*, 1864–1873 (*inclusive*).

	Total for 10 years.	Average Deaths per annum.
1. Fever, . .	3,780	378
2. Diarrhœa, . .	2,782	278
3. Scarlatina, . .	2,640	264

	Total for 10 years.	Average Deaths per annum.
4. Small-pox, . .	1,715	172
5. Whooping-cough, .	1,714	171
6. Cholera, . .	1,298	130
7. Measles, . .	1,190	119

Table XVII.—*Showing the Total Deaths, and Annual Average Number of Deaths from Seven principal Zymotics, in Ireland, for* 10 *years*, 1864–1873 (*inclusive*).

	Total for 10 years.	Average Deaths per annum.
1. Fever, . .	37,813	3,781
2. Scarlatina, . .	27,983	2,798
3. Diarrhœa, . .	19,482	1,948
4. Whooping-cough,	17,510	1,751
5. Measles, . .	10,048	1,005
6. Small-pox, . .	5,999	600
7. Cholera, . .	3,724	372

Fever is by far the most destructive: and the percentage of deaths of those attacked being low, the 3,780 deaths in Dublin represent an enormous number of cases, probably not less than 50,000. As fevers are fatal chiefly to adults, while scarlatina, measles, diarrhœa, and whooping-cough, are fatal chiefly to children, it is evident that the relative misery and loss produced by fever are greater than in the case of any of the other zymotics. Again, the endemic zymotics, or those constantly among us, any of which may assume the epidemic form, are far more destructive than those which appear only as epidemics; and however much it may be our duty to ward off cholera and small-pox from our shores, it is equally our duty, and far more important for our national prosperity and domestic comfort, that we should control these endemic diseases.

The conditions which influence the spread of zymotic diseases are numerous, but are easily classified; they belong

to either of two great classes—those belonging to place, or those belonging to persons or population.

A. Those belonging to place :—

1. Locality.
2. Facilities for drainage and water supply.
3. Age, condition, and construction of streets and houses.
4. Season and Climate.

B. Those which belong to persons or population :—

5. Density of population.
6. Proportion of pauperism.
7. Cleanliness.
8. Accommodation for the sick.

A.—1. *Locality.*—It is a well-established fact that the higher the situation above the level of the sea, the less the prevalence of zymotic diseases. This, no doubt, is chiefly owing to the facilities afforded by such situations for efficient drainage, and also to the fact that few large communities are so situated. As, however, the situation of all our towns and most of our villages has already been settled, we may almost leave this consideration out of the question. Their position can scarcely be at all effected by public measures, but the defects in situation may be counteracted to a great extent by sanitary measures. As an example of the effects of situation, Birmingham, which, from its elevated position, porous soil, and favourable aspect, has a system of natural drainage, although densely populated and without any particularly good sanitary system, is the healthiest of the large towns in the United Kingdom, usually escapes great epidemics, and has a low zymotic death-rate.

2. *Drainage and Water Supply.*—The great effect of proper drainage and water supply on the health of towns is shown by the instances given in Dr. Buchanan's Table (see

p. 117),[1] from which it appears, according to that author's report, that the health of a large number of English towns has been materially benefited by extensive improvements in drainage and water supply; endemic diseases have permanently diminished, and epidemics have fallen with lightness on these towns since the improvements have taken place. This is especially and almost invariably to be noticed in the case of enteric fever, diarrhœa, cholera, phthisis, and the remark applies also to infantile death-rate.

Table IX. shows the result in ten of the largest towns mentioned in the report.

3. *Age, Condition, and Construction of Houses.*—It is a notorious fact that old houses in old streets of old towns are the favourite haunts of zymotic disease, and there are other reasons for this besides the age of the houses, for it is here that we find poverty, hunger, and dirt, combined with overcrowding, all being promoters of zymotic disease. A comparatively new house, may too, from faults in original construction, want of drainage, and neglect of repairs and cleaning, become as bad as any old house.

From the records of the Cork-street Fever Hospital a list has been constructed of all the houses on the south side of Dublin from which cases of fever were admitted into the hospital during a period of two years.[2] These houses were marked on a map by red dots. Two lines intersecting the map were drawn, so that the point of intersection marked the centre of Dublin as it existed in A.D. 1610 ; the boundary of the city at this date was also marked on the map, and so was the boundary of the city in 1728. A glance at the map showed that by far the greater number of fever dots were concentrated in the area of the old city, the remainder being nearly all contained between the boundaries of 1610 and 1728, the next oldest part, and but few being situated beyond the latter line or modern part of the city. 1,190 of these fever houses were traced out; of these 122 were especially productive of fever,

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[1] *Ninth Report of the Medical Officer of the Privy Council for the Year 1866.* P. 35.

[2] *Lectures on Public Health, Royal Dublin Society.* 1873. P. 83.

no less than 70 being within the old city boundary. The worst fever streets in Dublin are to be found amongst the oldest; thus, Francis-street, which was fully built in 1610, has 28 infected houses out of 140. The Coombe, though not so old, and Meath-street, more modern still, though old, are remarkably productive of fevers. The same may be said of the old streets lying along the bank of the river, though not on the line of our modern quays. This is not merely applicable to fever, but it has been clearly ascertained that these also are the places where *all* zymotic diseases arise, and whence they spread. Thus a cholera map or a small-pox map would be almost precisely the same as a fever map. Of 124 fever nests, 58 at least have been also small-pox and cholera nests. This is true not only of Dublin but also of other large towns.[1]

The following, taken from the Report of the Dublin Sanitary Association for the year 1873, is an excellent example of the conditions which favour the spread of zymotic diseases:—

"October 4th, 1872.—*Nos.* 17 *and* 18, *Great Ship-street—Overcrowding—fever*—unfit for habitation in their present state.

No. 17—*Basement Storey* damp and filthy—sewage matter is said, at times, to ooze up through the flagging.

In the kitchen			*front*	2 persons live.			
,,	ground floor		*front*	7	,,	,,	3 children sick.
,,	,,	,,	*back*	4	,,	,,	—
,,	first	,,	*front*	8	,,	,,	1 person sick.
,,	,,	,,	*back*	3	,,	,,	1 person sick.
,,	second	,,	*front*	5	,,	,,	—
,,	,,	,,	*back*	5	,,	,,	—
,,	top	,,	*front*	5	,,	,,	—
,,	,,	,,	*back*	1 person lives			—

Total population consists of *forty* persons, *five* of whom are now sick, suffering chiefly from various forms of fever.

No. 18—*Basement Storey* uninhabited, but filthy. The population of the rooms is as follows:—

Ground floor—*front and back*—4 persons.					
First	,,	*front* . .	6	,,	
,,	,,	*back* . .	5	,,	
Second	,,	*front* . .	8	,,	
,,	,,	*back* . .	9	,,	
Top	,,	*front* . .	7	,,	1 case of fever.
,,	,,	*back* . .	4	,,	

[1] The *Lancet* Report on "Cholera Haunts and Fever Dens of London." Dr. Gairdner's "Fever Dens of Glasgow," *in British Medical Journal.*

Total population is, therefore, *forty-three.* Total population of both houses, *eighty-three*, of whom *six* are now ill.

In the rere of these two houses three cottages are situated.

No. 1 is inhabited by a family numbering *five* persons, one of whom is ill of fever in Cork-street Hospital, and a second was to-day removed to the Meath Hospital, suffering from phthisis. (She died October 7th, 1872.)

No. 2 has also *five* inhabitants—two of whom are now in fever—one in hospital, the other, a young child, at home. This, as the other cottages, is divided into two rooms by a wooden partition, not reaching to the ceiling. The total dimensions are 14 by 8½ by 11 feet, the space per head being only 262 cubic feet.

No. 3 has *seven* inhabitants, two of whom are now suffering from fever in Cork-street Hospital. The father is in extreme danger, having an attack of severe maculated typhus. The rooms in this cottage are very dirty compared with those in Nos. 1 and 2.

The total population of the holding 17 and 18, Ship-street, is exactly *one hundred* persons.

The sanitary accommodation consists of a Vartry-water tap, two privies (each with *two* seats), in average order, and one large ash-pit, which requires cleansing.

Your Sub-Committee would call earnest attention to the formidable outbreak of fever which has taken place in these houses—due, in a great measure, to the great overcrowding of the rooms, and to the defective sanitary condition of the basement story of the houses. No less than 11 per cent. *of the population are at present stricken down by fever.*

These houses are built on the site of an old graveyard ; they face the Ship-street Military Barracks, and a line of stables is situated to the south side of them."

Although the above examples are selected from city houses, yet where similar circumstances arise in connexion with country cottages exactly similar attacks of disease may be expected. Such outbreaks are, however, usually slightly diminished in intensity by the influence of the pure and plentiful air of the country.

4. *Season and Climate.*—As we shall devote a special chapter to the consideration of climate and meteorological conditions, in their relation to zymotic disease, we shall not further dwell upon this question at present.

B.—1. *Density of Population.*—Density of population seems to be the great promoting cause of zymotic disease. This is

shown by a comparison between 13 large towns of the United Kingdom, and between the various London districts as shown in Tables IV. and V. Of the 13 large towns—in 4 the density of population, as measured per acre, is above average; in 3 of these the death-rate is above average, and so is the zymotic death-rate; the fourth is Birmingham, which is an exception to all such rules. Of the 28 London districts—in 20 the density of population is above average; in only 12 of these is the total death-rate above average, but in 17 out of the 20 (or 85 per cent.) the zymotic death-rate is above average.

2. *Pauperism.*—The relations between pauperism and the prevalence of disease are interesting to every member of the community, but especially to those who have the administration of sanitary laws in Ireland, as by recent legislation the destitution authorities and the sanitary authorities are the same in the great majority of instances, and the sanitary staff is almost altogether constituted from the Poor-Law staff.[1] Pauperism and disease, especially preventable disease, are so intimately connected, that the increase of the one necessarily involves the increase of the other. It seems that preventable disease depends more upon pauperism than pauperism upon disease. In fact, pauperism being produced by any cause results in the production of disease, and the disease so produced, if it be a zymotic, by its spread produces a fresh crop of pauperism. This was proved on a gigantic scale by the great famine fever of Ireland, and has been proved over and over again in a smaller way by failure of food supplies, or depression of trade, in other places.

That pauperism has a considerable influence in promoting zymotic diseases may also be shown from a study of the London districts; for among 12 of these districts, in which the pauperism was above average, in 9 (or 75 per cent.) the zymotic death-rate was above average—not so great a proportion as in density of population, which gives 85 per cent. It is important to show that the density of population and pauperism do not correspond, for in the 20 districts in which the density of population

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[1] See p. 22, *supra*.

is above average, in only 8 is pauperism above average, and in 12 it is below. As might be expected, in these 8 both pauperism and density of population increased the zymotic mortality. Therefore, though density of population is not the exact out-growth of pauperism, yet where both are combined the zymotics prevail to the greatest extent.[1]

3. *Cleanliness.*—The next point is the effect of dirt in the promotion of zymotic diseases, and that dirt has a large share in its propagation there is no doubt. From the account given of the favourite haunts of zymotic diseases, it is evident that dirt in some form, or rather in many forms, is their most characteristic feature. Dirt may not be present in the ordinary sense of the word—that is, may not be very visible; but, nevertheless, the air, food, or water supply may be so impregnated with dirt as to make an apparently and naturally healthy locality a focus of disease. This will be more particularly demonstrated when treating of the origin and propagation of special forms of zymotic disease. The improvements in the public health following sanitary works, mentioned in Table IX. (p. 117), chiefly operate by the removal of dirt.

The above-described conditions are admitted by all as the promoting causes of zymotic diseases, but a considerable difference of opinion exists as to how these causes act. Some deny that any known insanitary condition will produce any specific disease, while others maintain that each zymotic has its specific cause, and, moreover, attribute particular diseases to particular causes. These causes must each be considered under the head of the disease to which it refers, when we shall be able to show that in a considerable number of diseases the circumstances of their origin are so well known, and the conditions under which they arise so narrowly defined that we can with considerable certainty predicate the occurrence of particular zymotics from the existence of particular conditions of life. It can easily be shown that persons or populations who continually live under insanitary conditions are more liable

[1] See Table, p. 105.

to all kinds of disease (zymotics especially) than those living under sanitary conditions; thus, town populations are more unhealthy than country populations, and persons living in badly constructed or dilapidated houses, or in spaces too confined for the healthy exercise of the animal functions, are more liable to disease than those inhabiting healthy dwellings. Those who deny a specific origin for disease do not usually deny the injurious effects of living under insanitary conditions, but declare these conditions to be only a favourable soil upon which any disease, when introduced from without by contagion or other cause, will flourish. It thus happens that one of the best gauges of the sanitary condition of any community is its power of resisting the introduction, spread, or destructiveness of an epidemic Numerous illustrations of this proposition can be obtained from the history of epidemics. Thus the destructiveness of small-pox, during the recent outbreak in Dublin and Cork, as compared with the large towns of England, can be explained only by the conditions of public health being less efficiently fulfilled in the former than in the latter towns.

TABLE XVIII.—*Mortality from Small-pox in the late Epidemic.*

Place	Population in 1871	Deaths from Small-pox	Ratio of Small-pox Deaths per 1,000 of the Population
London, - -	3,251,804	10,215	3·1
Liverpool, -	493,346	2,093	4·3
Dublin, - -	314,666	1,565	5·0
Cork, - -	91,965	871	9·5

Another example is derived from the effects of cholera epidemics, which fell with gentleness upon some, but with great destructiveness upon other places.

All this is true not only of large communities, but of small communities also, as illustrated in epidemics where contagion, apparently derived from the same source, will act with the greatest malignancy upon one and, with the greatest leniency upon another household. This is well shown

by the following example, taken from the address of the President of the British Medical Association, at the annual meeting at Norwich, in 1874. Dr. Copeman there said :[1]—"The village in which the following occurrences took place was at the time healthy. There was no fever in the neighbourhood, and the house was a recently built parsonage, of good dimensions, and placed on an apparently unexceptionable site. There was a water-closet within the house, well supplied with water from a large tank, its waste-pipe leading into a capacious well-glazed drain just outside the house, which carried its contents underground a long way off, into a ditch too far removed to be hurtful. But there were also two privies with open arches, through which their contents passed into an oblong square dirt-bin, situated very near the back door of the house, and a very few feet from the large drain above mentioned, which might easily have been used for the purpose of carrying all the refuse of these privies, as well as of the water-closet, to a safe distance from the house. Unfortunately, this very obvious and desirable arrangement was overlooked by the builder; and as one of these privies was used for the conveyance of all slops, etc., from the house, this bin, into which both fluid and solid refuse was admitted, was often very offensive. The family residing in this house consisted of the clergyman himself, his mother, his wife, six children (the eldest being about fourteen years old), and several servants. The second son had been at school in a market-town many miles off. But scarlet fever broke out there, and he was sent home. On his journey he became chilly and faint, reached home with difficulty, and then exhibited the usual symptoms of scarlet fever in a mild form, and recovered. Soon afterwards two of the other children and a servant took the fever, and in less than a week all three died. On January 20th I received the following note from the husband, the first intimation I had of what was going on :—'I have lost two children and a servant by scarlet fever during the past week, and my wife is now attacked by it. The surgeon says she has no unfavourable symptoms, but I should like much for you to come over by an early train to-morrow.' This was written on Sunday, January 19th, and just as I was starting by train on Monday morning I received another message by telegraph. The distance was too great for me to arrive before the afternoon, and ere I got to the house I was told that the wife was also dead. . . . . She had been dead an hour or two, a victim to the laryngeal form of the disease. The day before she had a bright eruption, and seemed to be going on well, but afterwards lost her voice, and died suffocated. I was then asked to see another child, seized with the fever that very morning. . . . He was quite sensible, but pallid, cold, and complaining of pain in one side

[1] *Brit. Med. Journ.* Vol ii. 1874. P. 195.

of his throat; the right tonsil was inflamed, but he could swallow, and took whey freely. His countenance bespoke the existence of a deadly poison in his blood; his pulse was very feeble, and although he was kept near a good fire, was covered with warm blankets, and had hot bottles to his feet, he remained cold and in a state of collapse. We applied turpentine round his throat, which, he said, relieved him, and when I left in the evening he was a little warmer, but I expressed my firm conviction that he was in great danger. The next evening . . . I received the following telegram:—'The little boy is dead; the eldest son is taken; please to come by the first train.' I arrived in the middle of the night, and found the eldest son sickening, but fortunately they had followed my advice, to remove him to another house, a few hundred yards from the parsonage. I stayed all night, and he was not worse. . . He went through a mild form of the disease, and recovered."

Many similar examples will occur to the minds of those who have been much in contact with contagious fevers. That the effect of living under insanitary conditions diminishes the chance of recovery, and increases the malignancy of the disease, is shown by the following quotation from the report on the small-pox epidemic of 1871-73, as observed in Cork-street Hospital.[1]

		General per cent. Mortality.	General per cent. Vaccination.
Dublin,	Cork-street,	21·6	81·8
	Hardwicke,	20·0	83·7
Cork,		22·5	68·1
London,	London (Small-pox),	18·8	91·5
	Hampstead (Fever),	19·4	79·4
	Homerton,	16·3	67·0

The difference in mortality between the Irish and English hospitals can be explained only by the insanitary state of Dublin and Cork, as compared with London.

4. *Accommodation for the Sick.*—Another promoting cause of zymotic disease is the want of suitable accommodation for the sick—namely, proper and easily expansible hospital accommodation for all forms of contagious diseases; the want of proper means of bringing patients to hospital; the want of proper means of disinfection, and of separating the sick and convalescents from contagious zymotics from the healthy. This will be referred to again under the head of Hospitals.

[1] T. W. Grimshaw, M.D., *Dubl. Med. Journ.* Vol. lvi. P. 14. 1873.

CHAPTER XII.

Special Zymotics.

Continued Fevers.—Three kinds of Continued Fevers.—Relation of Fevers to each other.—Typhus.—Typhus caused by Overcrowding.—Outbreak of Fever at Carlisle.—Black Assizes.—Period of incubation of Typhus.—Communicability of Typhus.—Enteric Fever.—Origin of Enteric Fever from Fæcal Contamination.—Examples.—Enteric Fever and Milk.—Contagion of Enteric Fever.—Relapsing Fever.—Relation of Relapsing Fever to Famine.—Cholera and Diarrhœa.—Their relation to Enteric Fever.—Cholera and Water Supply.—Diphtheria, Croup, and Pythogenic Pneumonia.—Their Cause.—Erysipelatous Diseases and Hospital Plagues.—Puerperal Fever.—Healthy Hospitals.—Exanthemata.—Scarlatina.—Relation between Scarlatina and Slaughter-houses.—Measles.—On the relation of Measles to Fungi.—Small-pox.—Vaccination.—Relative mortality of Vaccinated and Unvaccinated.—Re-vaccination.—The Beneficial Effects of Re-vaccination.

We shall now proceed to treat of the different zymotics separately.

(*a.*) Continued Fevers.—This is not the place to enter upon the discussion of the views still held by some as to the specific identity of various forms of febrile diseases, or even the identity of those diseases commonly known as continued fevers—namely, simple continued, typhus, enteric, and relapsing fevers. The view we adopt is that there are three specific diseases—typhus, enteric, and relapsing fevers—included in the title "Continued Fever." Now, why do we deny to "simple continued fever" a specific position? We believe that the fever called "simple continued" is in every case either a secondary fever attending some disease—not a specific fever, or a mild or badly marked form of one of the three specific fevers, more commonly (perhaps always) typhus

or enteric fever. That such is the case is pretty well shown by the following statement, compiled from the records of Cork-street Hospital, which shows that it nearly always prevails in conjunction with typhus and enteric fevers, but especially with typhus. Of 42 houses, furnishing more than 5 cases of fever each—

13	houses	furnished	cases of	three kinds of fever.
19	,,	,,	,,	simple and typhus.
4	,,	,,	,,	simple and enteric.
4	,,	,,	,,	typhus and enteric.
2	,,	,,	,,	simple only.
0	,,	,,	,,	typhus only.
0	,,	,,	,,	enteric only.

19 houses furnishing typhus, furnished also simple fever.[1]

Although "simple continued fever" is comparatively harmless, yet the officer of health must look upon its prevalence as an indication of insanitary conditions, and it should at once lead him to inquire into the surroundings of the patient, when he will probably find a ready prepared *nidus* for typhus or enteric fever.

1. *Typhus.*—The primary condition necessary to the production of typhus fever is overcrowding.

Although overcrowding favours the spread of all kinds of contagion, yet in no disease has it been so frequently and closely associated with the first appearance of disease as in typhus. Dr. J. Heysham (1781) traced an outbreak in Carlisle to a house inhabited by six families, and where no windows that could be built up were left open, consequently there was no ventilation whatever. Typhus began here without any trace of contagion, and then spread through the rest of the town. In 1859 typhus fever, which for some months had disappeared from Edinburgh, arose in a poor locality where the houses were overcrowded, and in no instance was there any suspicion of contagion.

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[1] T. W. Grimshaw. *Prevalence and Distribution of Fever in Dublin.* P. 26. 1872.

Important evidence in favour of the view that the typhus fever poison may be generated from overcrowding, may be derived from the various records of what have been termed "Black Assizes,"[1] where judges, juries, and others in court contracted fever from the exhalations from the prisoners, who, in the days prior to the time of Howard, frequently suffered fearfully from what was termed "gaol fever" in those days, but which was nothing more or less than typhus produced by the overcrowding of gaols. The latest, therefore, most reliable account of a Black Assizes is that of 1750 at the Old Bailey, where 100 prisoners were tried. These were either placed at the bar or confined in two small rooms opening into the court. Many present were affected with a noisome smell. Within a week or ten days many of those present were seized with typhus. More than forty persons died, including the Lord Mayor, two of the judges, an alderman, a sub-sheriff, and several of the jury. Neither the prisoners on trial nor any of those in gaol were affected by fever.

From this account it appears that the poison produced in those prisoners by overcrowding was exhaled by them, and affected those in their vicinity without any other apparent cause.

The following is a good example of the conditions under which typhus fever is produced :—

A court, 11 feet wide, with all matters as to drainage and water supply in good order, and recently constructed. Fever arose in house No. 10, which consisted of two floors connected by a narrow staircase.

	Cubic Feet.	
Ground floor :		
Front room,	595	Occupied by a mother and six children and grandmother, who came to nurse those who were sick.
Back do.,	544	
Upper floor :		
Front room,	680	Occupied by a man and his wife.
Back do.,	497	

Before the arrival of the grandmother each had 163 cubic feet, after her arrival 142 cubic feet. Windows had all been shut up for the winter, and there was no means of ventilation. The rooms had the well-known animal odour of overcrowded houses.[2]

This is only one sample of the conditions under which typhus is produced, selected as an extreme instance, but others could be easily quoted. The records of the Dublin Sanitary Association afford instances of

[1] Murchison. *Continued Fevers of Great Britain.* Second Edition. P. 104, *seq.*

[2] *Loc. cit.* P. 100.

typhus outbreaks arising where overcrowding was not so extreme as in the above example, the space for each individual amounting to 250, or nearly 300 cubic feet, but in such cases the surrounding insanitary conditions increased the liability to the disease. Further proofs of the intimate connexion between overcrowding and typhus are derivable from the valuable Tables of Dr. Murchison, with regard to the density of population in the localities furnishing cases of typhus fever to the London Fever Hospital, and also from the fact that typhus is more prevalent in winter than in summer, overcrowding being more common in the former than in the latter season.

These latter proofs are, of course, applicable also to all contagious zymotics, typhus being one of the contagious zymotics. A large number of the cases are produced by contagion, especially when favoured by insanitary conditions. Thus, typhus arising among members of the higher classes of Society almost invariably has its origin in contagion. The distance to which the typhus poison can be transmitted through the air is very limited, so that there is absolutely no danger of its being communicated from the inmates of one dwelling to those of another, or carried by a third person, and there is even but slight danger to the attendants in typhus wards, provided that the ventilation is sufficient, although the medical attendants and nurses who are in absolute contact with the sick are constantly attacked by the contagion. The disease is also communicable through foul clothing or bedding, and persists for some time in rooms, or buildings, or ships which have been occupied by, or vehicles which have conveyed, typhus patients. The period of incubation is about twelve days, and it is said to extend even to twenty-one days, but such cases are extremely rare. Many high authorities are of opinion that patients convalescent from typhus are especially liable to communicate the disease, and the experience of the convalescent wards of some fever hospitals tends to confirm this opinion. This should be borne in mind when making provision for convalescents in fever hospitals.

2. *Enteric Fever.*—The evidence that enteric fever is the

direct product of food, drink, or air contaminated by the presence of decomposing sewage matter, or by the miasma exhaled thereby, is, if possible, stronger than the evidence of the production of typhus by overcrowding; because in the case of the latter many other of the causes favouring the spread of zymotic diseases co-exist, but, with regard to the former, nearly all other causes except the presence of the decomposing matter can be generally excluded.

While typhus is a disease almost exclusively belonging to the poor and badly fed, enteric fever makes its appearance in all ranks of society. Careful inquiry almost invariably discovers a pythogenic origin.

A few examples will illustrate this. An outbreak of enteric fever in a large educational establishment in Dublin arose under these circumstances :[1]—

The class-rooms in which the various students attended lectures were situated in one building. In this same building some of the male students resided. The remainder of the male students resided in a separate house in another street. The female students resided in a third building at a considerable distance from the building containing the lecture-rooms.

In the area of the building containing the lecture-rooms were situated latrines for the use of the male students only ; there was also a pump in this area, but at some distance from the latrines, from which drinking water was occasionally obtained. This pump was partly supplied by well-water and partly by Vartry water, but there was no evidence that this pump supplied the usual drinking water for the male pupils. The situation of the latrines was so low (only slightly above high water mark) that their drainage was driven back at each rise of the tide, and when the tide rose very high the area itself was flooded with sewage matter of the most disgusting character. Thus all the gases from the decomposing sewage was mixed with the atmosphere breathed by the unfortunate pupils each time they visited the area. The result was that many (14 out of about 70) of those who frequently visited this area were attacked with fever, and of these 4 died. None of the female students and none of the others who frequented the lecture-rooms and who did not visit the latrines, were affected with fever.

As instances of localised outbreaks of fever depending upon sewage

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[1] *Lectures on Public Health, Roy. Dubl. Soc.* 1873. P. 94.

contamination of water, those of Terling, Guildford, and Winterton, mentioned in the 10th Report of the Medical Officer of the Privy Council, may be quoted.

Terling[1] is a village in Essex, with a population of about 900 souls, is very much isolated and cut off from communication with neighbouring localities, so much so that most of the inhabitants are related to one another by marriage ; their physical and moral characters are both very low. The inhabitants are nearly all farm-labourers, living in houses constructed, with few exceptions, of lath and plaster, or worm-eaten wood. The people are all badly fed. The cottages are surrounded with almost every conceivable nuisance. "Slops and ashes," says Dr. Thorne, the Inspector who writes the Report, "thrown down in unpaved yards and gardens, manure heaps, cesspools, and masses of decaying vegetable matter "—all rubbish and excreta—lay scattered about in all directions. "Surrounding one cottage and within a radius of 20 feet, I found one pig-sty, three manure heaps, two cesspools, and a privy, the contents of which extended for 12 feet down an adjoining field."

In the centre part of the village, as shown in the map accompanying the Report, each cottage or each group of cottages had its own well, and if the ground was at all undulating this was sure to be situated at the lowest point. All were sunk in the gravelly stratum (which underlies the village) and were, as a rule, uncovered, lined with loose bricks (without mortar or cement), depth 5 to 40 feet, according to height of ground. On a higher level, and surrounding these wells, were all the nuisances mentioned above, the drainage from which, owing to the porous nature and lie of the ground, as a matter of necessity, found its way into the wells. None of the outlying houses had wells, but derived their water supply from pools in the fields frequented by cattle and described as "nothing better than stinking pools." Overcrowding was frequent, the sick sometimes being two or three in a bed ; in some places 82 cubic feet of space were allowed to each person.

In this village 208 cases of fever of a very bad type occurred, besides diarrhœa ; and 10 cases of fever in Terling-place, the neighbouring residence of Lord Rayleigh.

The first case of enteric fever arose in the person of Lord Rayleigh's dairy-maid, who drank the water taken from the river Lea in the immediate vicinity of the entrance of a sewer. This dairy-maid had been in Somersetshire, but had returned three weeks before she got sick, and as the cases that followed next had no connexion with this case, the supposition of the introduction of the fever by this person is unlikely ; it

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[1] *Loc. cit.* P. 41.

is more than probable she had also opportunities of using water from some of the village wells.

The epidemic followed the rising of the wells after their having been lowered by long-continued dry weather, the rising of the water being caused by wet weather, which, while it filled the wells with rain water, also washed all the dirt in the vicinity into them.

The first cases which arose after that of the dairy-maid, were in five cottages built of wood, surrounded by pig-sties and dirt, all dirt being thrown out into an unpaved yard sodden with dirt, in which yard was situated the well for all the inhabitants of the row.

At No.	1	there was	1	case and	0	death.
„	2	„	1	„	1	„
„	3	„	2	„	1	„
„	4	„	3	„	0	„
„	5	„	2	„	0	„

The well had dried up, and had not been used for two months, and water was obtained from a well in the neighbourhood where no great diminution of the water had taken place.

On November 19, a woman was ill—not of the fever—in one of these five houses, and water was wanted for cleansing purposes, but none was in the well. On November 26, water was found to be in the well, and was immediately used for drinking purposes. Ten days after using this water, or at the end of the time usually allowed for the incubative stage of enteric fever, the first case of fever arose in the person who had used the water; the other cases in these five houses immediately followed the first case.

The inhabitants of another set of houses in the immediate vicinity, who were deprived of their own water supply by the drought, got water from the same well that the first set of houses derived their supply from before the 26th of November. So long as they were thus supplied no fever appeared, but 14 days after the water returned to their own well, fever appeared amongst them in due course. The epidemic spread in the same way to the rest of the village, and Lord Rayleigh's house became infected in a similar manner, those being affected only who used water from a well contaminated by sewage matter by leakage from a tank in the neighbourhood of the pump. From the peculiar construction of the house the portion of the inhabitants supplied with water from this source were completely isolated from those in the rest of the house.

Of course all the water in this village must have been contaminated with sewage matter for years. Why then did fever not arise before? The answer is simple. The wells were never before emptied by drought

and quickly filled by wet weather, all the dirt being thereby concentrated in the first washing of the sewage-sodden earth.

An almost similar, though not so fatal, epidemic arose at the village of Winterton.[1] A row of four houses was supplied with water from a pump well, within 14 feet of which were situated one open drain, one open ashpit, two pig-sties, three privies, and one cesspool, all from 18 inches to 3 feet on a higher level than the well.

In No. 1	there lived	3	persons,	2	of whom had fever.	
2	„	4	„	4	„ „	and 1 died.
3	„	7	„	7	„ „	
4	„	4	„	0	„ „	

The people in No. 4 would not drink the water because it had a bad taste, and they therefore escaped the fever.

Guildford[2] affords another example of how much influence dirty water has in producing enteric fever. This town, in the year 1861, had a population of 9,000 inhabitants living in 1,675 houses. It stands on chalk on the side of a hill. The stratum of chalk afforded a natural drainage for the town, all sewage being conducted into cesspools, which drained themselves into the chalk, and therefore remained nearly always dry, and were never known to be offensive. There was no system of drainage at Guildford at the time of the outbreak. The water supply was derived from several sources—

1st. From an old well sunk in chalk at the bottom of the hill, from which water was pumped by a water-mill.

2nd. A new well from which water was pumped to the upper parts of the town by engine power.

3rd. From private wells attached to the houses.

928 houses were supplied from the first two sources, 747 from the private wells.

Some enteric fever is always present in the poorer parts of Guildford.

The outbreak occurred in the last days of August in the upper part of the town, where it had not previously prevailed, and where the wealthier part of the population resided. There were in all 264 cases of fever ; of these 177 were in the 330 houses supplied by the high-service water supply, 30 in 598 houses on the low-service water supply, and 57 in 747 which received no water from the public water works. This shows at once that those receiving the high-level supply were more liable to enteric fever than any others ; and excluding the ordinary cases, and the case of children who attended school in the infected districts, but who resided elsewhere, nearly all the fever arose among those drinking the

[1] *Loc. cit.* P. 28. [2] *Loc. cit.* P. 34.

high-service water which was drawn from a reservoir in the high part of the town, kept filled from the well by the pumping engine on the low ground.

Up to August 1st these people had a constant supply of water from the high-level reservoir ; on that day the engine broke down, and the water supply from the old well and wheel was resumed. At this time there was still some water left in the high-level reservoir, which was left there exposed to the influences of the heat of August weather, which would promote decomposition of any organic matter it might contain. On the 17th of August the water-wheel broke down, and thus the second supply to the occupiers of the high-level district failed. Half a loaf being better than no bread, the small residue of dirty water was supplied to those houses, and then followed the fever. The well from which the water had been pumped was found to be contaminated with sewage, which was comparatively harmless until concentrated and acted upon by exposure to the summer heat while it lay undisturbed for nearly three weeks in the reservoir.

Two points are here illustrated :—1st, how sewage contamination poisons water ; and 2nd, how this poison is increased in intensity by decomposition and concentration.

An outbreak of enteric fever at Islington has been shown by Dr. Ballard to have depended upon the sewage contamination of milk from a dairy-yard pump, which had been used to increase the value of the milk to the dairyman, at the expense of the health and lives of his customers.

Of 2,000 families resident within a quarter-mile radius of the dairy-yard, 142 were supplied with milk from this dairy ; of these, 70 were invaded by enteric fever within 10 weeks.

"It is remarkable," says Dr. Ballard,[1] "how typhoid picked out the customers of this dairy ; thus, in one long road and a street issuing from it, at a distance of a mile or more from the dairy, it supplied three families—of these, two had typhoid. It supplied four families in a neighbourhood of about 70 houses—of these, 3 had typhoid ; it supplied 4 families in a row of 9 houses, typhoid occurred in 2 of them ; and in the other 2, cases of a mild febrile character occurred."

And so on in many other instances. Dr. Ballard also shows that only those who consumed the milk were affected by fever, and of those who worked in the dairy-yard and did not use either the dirty milk or dirty water none had the fever. On examination, Dr. Ballard found that the

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[1] *Typhoid Fever in Islington traced to the Use of Impure Milk.* By E. Ballard, M.D. London : Churchill. 1871.

pump from which the milk was watered was contaminated by sewage infiltration into the tank from which the pump water-was derived.

Dr. Russell, Medical Officer of Health for Glasgow, has shown that of 72 families in 5 streets supplied by a dairyman in whose family enteric fever prevailed, 22 had fever ; and in 32 families supplied by this dairyman there arose 36 cases of fever.

A still more remarkable case occurred in the summer of 1873, in London, in the Marylebone district, by the distribution of sewage-poisoned milk by the Dairy Reform Company, in which the families of numerous medical men suffered.[1]

The fatal activity of milk as a vehicle of contagion has also been most carefully and scientifically investigated by Dr. Taylor, of Penryth, Dr. Bell, and Dr. Thorne. It has been shown that not only typhoid but small-pox, scarlatina, and even cholera, have probably been communicated to people through the medium of milk. It is, therefore, of the utmost public importance to inquire into the sanitary condition of the cow-sheds and dairy-yards.

There is now no doubt that many cases of fever and diarrhœa are produced in a similar way by the sewage contamination of milk. Anyone who has visited Dublin dairy-yards must be convinced that the milk derived therefrom must run great chances of sewage contamination of some sort, for filthier places can scarcely be imagined.

Where causes of enteric fever and typhus co-exist, both diseases will arise at the same time, and sometimes even in the same person.[2]

Thus, there were admitted into Cork-street Fever Hospital eleven members of one family, from a house in Bishop-street, Dublin. Some of these patients had typhus, some enteric, and two of them both forms of fever. On examining the house, it was found that the conditions necessary for the development of both diseases co-existed. The basement of the house was saturated with sewage, and had been so for some time, and the family of eleven were crowded into two small and indifferently ventilated rooms.

Enteric fever seldom assumes the epidemic form, and is generally characterised by appearing in isolated outbreaks.

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[1] *Brit. Med. Journ.* Vol. ii. 1873. P. 206.

[2] *Irish Hosp. Gaz.* 1873. Pp. 17 and 36.

A considerable difference of opinion formerly existed as to whether or not enteric fever was contagious. This question may now be considered as settled in the affirmative; for although this disease is much less communicable than other zymotics, yet it is communicated, probably by exhalations from, and certainly by the injection or absorption of the discharges from the bowels of, an infected person, or from the exhalations from these discharges. That the disease is not easily communicated through the air is shown by the freedom from attack of persons in attendance on enteric fever cases. Thus, in Cork-street Hospital, during a period of two years, fourteen nurses and attendants were attacked with typhus, and only *one* with enteric fever, although the cases of enteric fever amounted to about one-half the number of typhus cases treated during that period. That the disease is eminently communicable through the discharges from the bowels is proved by many instances, especially those mentioned by Dr. Budd in his work on typhoid fever.[1] In some cases the disease followed the course of contaminated brooks used for drinking purposes; and in one remarkable instance a large number of persons attending a ball at Cowbridge were attacked with enteric fever in consequence of using water from a well which had been contaminated by the evacuations of a patient suffering from the disease.[2] There are, however, such innumerable instances (many detailed by Dr. Murchison) of enteric fever arising in conjunction with sewer exhalations or fæcal infection of water, where the possibility of the introduction of enteric fever poison is excluded, that there can be little, if any, doubt that the introduction of decomposing fæcal matter, or its miasm, into the system, will of itself generate the disease. These are matters of special importance, when taken in connexion with questions of drainage or water supply.

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[1] *Typhoid Fever.* By W. Budd, M.D. London: Longmans. 1873.
[2] *Loc. Cit.* P. 70.

3. *Relapsing Fever.*—This disease is known to arise only under conditions of great privation, and it is as much as typhus a disease of the poor and destitute. It is, however, communicable, and has often attacked persons living under perfectly comfortable and sanitary conditions, having been derived by contagion from their poorer neighbours. It certainly arises *de novo*, and always under precisely the same circumstances; whenever famine occurs in any part of Europe relapsing fever is an almost inevitable sequence. Although typhus is almost as constant a follower of famine as relapsing fever, yet the latter invariably precedes the typhus, and must be looked upon as the direct outgrowth of famine. Writing, as we are, especially for Irish sanitarians, it is scarcely necessary to refer to the fevers of the great famine of 1846 and 1847, when so many thousands were attacked by relapsing fever.

(*b*.) CHOLERA AND DIARRHŒA.—1. *Cholera.*—In close relation to enteric fever as to causation, stands cholera. The most constant condition connected with the spread of cholera is an impure water supply, or a supply contaminated with sewage matter. It cannot be asserted that in these countries dirty water produces cholera, but it certainly promotes the disease, whether by containing its germs, or merely by affording a suitable and apparently necessary soil for the disease to grow upon.

This has been demonstrated by the various effects produced in London by the different cholera epidemics of 1849, 1854, and 1866, on each district, according to the nature of the drinking water supplied to the inhabitants. Mr. Simon investigated this point in his *Report on the Cholera Epidemics of London, as affected by the Consumption of Impure Water*, published in 1856. This Report was the result of a most painstaking and lengthy inquiry into the minutest details of water supply, population, and distribution of cholera in 1849 and 1854, in the London districts lying south of the Thames. A similar Report by Mr. Radcliffe has been published in the

Report of the Medical Officer of the Privy Council for 1866, showing the connexion between the diffusion of cholera and impure water supply in the east end of London, in the cholera epidemic of 1866.

In the epidemics of 1849 and 1854 cholera fell with the greatest severity on the portion of London lying south of the river, under the following circumstances :—

Two companies supplied this district (which comprises St. Saviour's, St. Olave's, and St. George's, Southwark ; Bermondsey, Newington, Lambeth, Wandsworth, Camberwell, and Rotherhithe) with water. The competition was great between these two companies ; so great that out of thirty-one sub-districts, there were but eight which had only one company's mains within it, and in many cases the mains of both companies ran parallel in the same streets, supplying about an equal number of the houses. Thus the populations supplied by the two companies were so intimately mixed, that with the exception of the water supply the conditions were identical. We have thus a most perfect arrangement for testing the influence of bad water in promoting cholera. The two companies in question were the Lambeth Company, and the Southwark and Vauxhall Company, supplying a population of about 466,000 in 1849, and about 511,000 in 1854.

In 1853 and 1854 the Lambeth Company, which derived its supply from the Thames at Ditton, a source pure (dirty though it may be) in comparison with that of the sister company, supplied 24,854 houses, comprising a population of 166,906 persons, among whom there occurred 611 cholera deaths, being at the rate of 37 to 10,000 persons living.

The Southwark and Vauxhall Company derived their supply from the Thames at Battersea, which was "found to be of almost incredible foulness," swarming with living things, and filled with particles of dirt. In 39,726 houses, comprising 268,171 persons, there occurred 3,476 cholera deaths, or at the rate of 130 to every 10,000 of those living, or about three and a half times as many as among those drinking the better water.

In 1854 the Lambeth Company gave the best water, but in 1849 it gave worse than the Vauxhall Company, for the Lambeth Company during the interval moved their works up the river, while the Vauxhall Company remained where they were, and even this source became more impure from the increased drainage poured into the Thames by the increased population of London. Accordingly, we find that in the epidemic of 1849, in the houses of the Lambeth Water Company's tenantry, there died no less than 1,925 persons, although the population was less than in 1854, when but 611 died of cholera.

In 1849 there died among the Vauxhall Company's tenantry 2,880, or

less than the 3,476 of 1854; making all allowances for increased population, the mortality was higher than 1849, and the water worse. It is thus clear that, in the southern districts of London, where the water supply improved, cholera was less, and where it became worse, cholera was more prevalent. In 1866, when, by the enforcement of a new Act of Parliament, the Vauxhall Company had been compelled to obtain a new supply, and the Lambeth Company had improved its supply, there was but little cholera on the south side of the Thames. On the other hand, a dirty water supply poisoned the greater portion of the east end of London on the north side of the Thames, as shown in Mr. Radcliffe's Report.

The East London Water Company supplied two districts; both of these were infected by cholera, one severely, the other but slightly. There were two sets of reservoirs—one at Lea Bridge, the other at Old Ford. The district supplied from Lea Bridge was slightly affected; that supplied from Old Ford was terribly swept by the epidemic. But why was this when the water was from the same sources in both cases, and why did not cholera always pervade the population supplied from the Old Ford reservoir? The Old Ford reservoir was contaminated by sewage from the River Lea, which at that point is a sort of canal, into which drains emptied themselves, and which were possibly even contaminated by the drainage from the first cholera cases. It was not until this reservoir was used, in consequence of a short supply of water, that cholera spread through the district. A map accompanying the Report shows, by shadings, the various degrees in which cholera invaded the different districts of London in 1866, and graphically demonstrates how fatally the districts supplied by the Old Ford reservoirs of the East London Water Company were affected.

The story of the Broad-street Pump by Dr. Snow further proves the influence of dirty water in spreading cholera, as also did a special outbreak in connexion with a pump in Duke-street, in Dublin.

Valuable evidence in support of the connexion between cholera and water supply is given in Dr. Pettenkofer's papers on the connexion between cholera and ground water; as also the instructive paper by Dr. Mapother on the relation between old rivers and sewers, and the distribution of cholera in Dublin, in which he showed the predilection of cholera for these sites.

It must now be considered as established, that cholera is contagious, and equally well established that it does not originate *de novo* in Europe. Its existence seems to be incompatible with the temperature of European winters, unless specially nursed by artificial temperatures, maintained

for domestic purposes, as appears to be the case in Russia, where there seems to be some ground for believing that cholera has been domiciled for some years past. At the meeting of the International Sanitary Conference, held in Vienna, in July, 1874, the following conclusions with regard to cholera were arrived at:—

1st. It does not originate "*de novo*" in any country, except India.

2nd. It is communicated by human intercourse with diseased persons, not by healthy individuals, but possibly through infected clothing or food.

3rd. It is communicated by the bodies of those who have died of the disease.

4th. There is no evidence that it is carried by the air.

5th. The period of incubation is very short.

6th. Sanitary measures and disinfection can limit its spread.[1]

The foregoing conclusions may be considered as undeniable, having been arrived at after full discussion by the most distinguished authorities in Europe. They must, therefore, be the guide in carrying out all sanitary measures for the prevention of this disease.

2. *Diarrhœa.*—This disease runs parallel with cholera and enteric fever; it is in itself an extremely destructive disease, especially in the summer, and the degree of the prevalence of summer diarrhœa (or, as it is called in its severe forms, *English cholera*, *cholerine*, or *cholera nostras*) is generally considered by sanitarians as an important indication of the sanitary condition of a district, especially of a town district; but its importance in this respect is overrated by many. The absence of summer diarrhœa cannot be taken as proof of the healthiness of a population, though its prevalence shows that the sanitary condition of a district is in a dangerous state, and that a slight introduction of contagion would probably

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[1] *Lond. Med. Rec.* Aug. 5. 1874. P. 478.

light up a destructive epidemic of cholera or enteric fever. Epidemics of cholera and enteric fever, especially of the former, are always accompanied, and generally preceded, by the prevalence of diarrhœa.

(*c.*) Diphtheria, Croup, and Pythogenic Pneumonia.—These diseases have been grouped together—firstly, on account of their relation as zymotic diseases affecting the respiratory organs; and, secondly, as diseases having apparently a common origin—namely, inhalation of sewer gases.

1. *Diphtheria.*—The records of epidemics of diphtheria have frequently shown the close relationship between it and bad drainage, with exhalations from decomposing sewage. A good example of this is afforded in the case of an outbreak of diphtheria at Waltham Abbey, reported by Dr. Sanderson.[1] In this case the possibility of contagion was excluded. Diphtheria being contagious, may, of course, arise independently of sanitary conditions.

2. *Croup.*—The close pathological relation between croup and diphtheria, and the prevalent belief on the Continent as to the contagiousness of the former, together with its epidemic character, point to an origin similar to that of the latter. Although there is scarcely any positive evidence as to the pythogenic origin of croup, yet the recurrence of this disease in any particular locality should lead to careful inquiry into the state of its sewerage.

3. *Pythogenic Pneumonia.*—That pneumonia of a specific type may arise from the inhalation of sewer gases, seems now to be an established fact, although one as yet little known. An outbreak of this disease in a school at East Sheen, consequent on improper ventilation of a sewer in too close proximity to the school, has lately been recorded.[2] A remarkable feature in the history of this outbreak was, that the probability of its occurrence was

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[1] Vide *Eighth Report of the Medical Officer of the Privy Council*, 1865.
[2] *Medical Times and Gazette*, April 4th and June 20th, 1874.

predicted by Sir W. Jenner, who was consulted as to the possible results of making an opening into the sewer. The prevalence of this form of pneumonia in the spring and summer months, when ordinary pneumonia is absent, the extremely low character of its symptoms, its prevalence coincidently with, and its frequent complication of, enteric fever, together with the insanitary conditions under which it arises—all point distinctly to its pythogenic nature.

(*d.*) Erysipelatous Affections.—Under this head are included not only erysipelas properly so-called, but also the various forms of hospital plagues—namely, hospital gangrene, pyæmia, and puerperal fever. All these diseases result from over-crowding and want of proper sanitary provisions in the hospitals. They not uncommonly arise outside hospitals, and come under the notice of private practitioners, but when so met with, careful inquiry will discover, either that the patient has been living under peculiarly insanitary conditions, or that the disease has been communicated by contagion. Many high authorities have considered that the prevalence of these forms of disease is the direct result of treating a large number of surgical or obstetric patients in the same building. Hence a discussion has arisen as to whether large hospitals are, or are not, the most efficient means of providing for the sick poor, especially in the case of those suffering from surgical injuries or operations, or lying-in cases. It has been affirmed by the opponents of large hospitals, that the mere bringing together of a large number of sick persons is sufficient to produce erysipelatous affections, and thereby to increase the mortality, and that the mortality from similar cases treated in private is less than in hospitals. The opponents of this view affirm, that although the mortality from erysipelatous affections is high in many hospitals, possibly higher than in private practice (although this is denied by some), that this high mortality is owing to improper sanitary arrangements in those hospitals, and that, if proper attention were given to all sanitary details,

erysipelatous diseases would not be more frequent in large than in small hospitals, or in private practice.

Lying-in hospitals are taken as the great test of the truth of these views, and the Rotunda Lying-in Hospital, Dublin, in particular. It has been shown that for many years puerperal diseases have been too common in that institution, and this has been attributed to the fact of bringing together so many puerperal women, and considerable force is added to this view by the fact that the more numerous the deliveries, the more prevalent was puerperal fever, as shown by Dr. Evory Kennedy.[1] Two remarkable exceptions to this rule, however, almost prove that this extreme prevalence of puerperal fever was to a great extent, if not altogether, owing to the want of proper sanitary precautions. These exceptions occurred during the Masterships of Dr. Collins and of the present Master, Dr. George Johnston. During the Mastership of the former puerperal fever was reduced to a minimum, and *trismus nascentium*, also a disease of unhealthy hospitals, was abolished by the extreme and minute sanitary precautions taken. The present Master has carried out sanitary measures even to a greater extent than Dr. Collins, with the result of complete absence of puerperal epidemics, and of late years contagious zymotics have not spread when accidentally introduced into the hospital, as shown in the notes of the hospital, from Dr. Churchill's Address to the Obstetric Section of the British Medical Association, at Norwich.[2] It may, therefore, be affirmed that hospitals, as such, do not breed erysipelatous diseases, and that with proper sanitary precautions the origin of these diseases may be as effectually prevented in large hospitals as in private houses.

Mr. Simon, in his Report of 1864, says:—"That which makes the healthiest house makes likewise the healthiest hospital; the same fastidiousness and universal cleanliness, the same never-ceasing vigilance against the thousand forms in which dirt may disguise itself in air and soil and water, in walls and floors and ceilings, in dress and bedding and furniture, in pots and pans and pails, in sinks and drains and dust bins, is but the same principle of management, but with immeasurably greater vigilance and skill; for the establishment which has to be kept in such exquisite perfec-

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[1] *Hospitalism and Zymotic Disease.* London: Longmans. Dublin: Fannin and Co. 1869.

[2] *Brit. Med. Journ.* Vol. ii. 1874. P. 223.

tion of cleanliness is an establishment which never rests from fouling itself; nor are there any products of its foulness, not even the least odorous of such products, which ought not to be regarded as poisonous."

(*e.*) EXANTHEMATA.—Under this head are included scarlatina, measles, and small-pox.

The origin of these diseases is in every case obscure. Some plausible attempts have been made to explain the origin of scarlatina and measles, but no reasonable explanation has yet been offered of the origin of small-pox. The first two cannot be considered as preventable, but are certainly controllable through the means available for the prevention of contagion. Small-pox, on the contrary, must be looked on as the most preventable of all diseases.

1. *Scarlatina.*—The only miasm which has as yet been shown to have any special connexion with scarlatina is that arising from the decomposition of slaughter-house refuse. This origin for scarlatina was first suggested by Dr. Carpenter, of Croydon. Scarlatina has also been attributed to overcrowding; but we have not yet been able to convince ourselves that the prevalence of scarlatina in connexion with overcrowding is to be attributed to any other effect of overcrowding than the well known tendency of that condition to favour the spread of contagion. Dr. Carpenter has shown in 9 cases of localised epidemics of scarlatina, where the possibility of contagion seemed to be excluded, that the presence of decomposing slaughter-house refuse was the only assignable cause. It is unnecessary to give the details of these cases, but the most of them occurred under circumstances where all other sanitary arrangements were good.

This origin for scarlatina is further confirmed by an analysis of the death registry of No. 2 district of the south Dublin city district, undertaken by Dr. Maunsell, who found that out of 6,000 deaths registered in that district during the nine years, 1864 to 1872 inclusive, there were 268 deaths from scarlatina; of these 95, or more than one-third, occurred in the immediate neighbourhood of the slaughter-houses

connected with the Clarendon, Castle, and Blackhall Markets, and another limited neighbourhood containing but one slaughter-house. The area in which these deaths took place is but one-eighth of the whole district. Two of these slaughtering districts are not remarkable for the prevalence of other zymotic disease.

The extreme contagiousness of scarlatina cannot be too much insisted on by sanitarians. Its period of incubation seems to extend from a few hours to ten days, or even more. The vitality of its contagiousness is so great that it remains in activity for many months after its departure from the infected person. It is communicable through any of the discharges from the sick, and by the exfoliated cuticle. The possibility of the contagion of scarlatina being carried by the discharges from the bowels is a matter of the greatest importance, when considered with reference to sewerage. The communicability of the disease through a third person must be especially remembered, and in this respect it resembles measles. The only preventive measures applicable to scarlatina are those depending upon effective isolation of the sick, and thorough disinfection.

2. *Measles.*—Next we have to see under what circumstances measles arises. The only conditions yet shown to be intimately connected with measles are decomposition of vegetable matter, especially straw, and the presence of the lowest forms of fungi, commonly called mustiness.

Dr. Salisbury, of Newark, Ohio, United States, has demonstrated his ability to produce measles or a disease undistinguishable from it.[1]

Dr. Salisbury refers to the various fungi which attack grain, as smut and bunt; to those attacking animals, as Mursadine (*Botrytis Bassiana*) attacking the silkworm; and the mould which kills the house-fly in autumn (*Sporendonema muscæ*), and which we see as white rings around the animal's body, and finally on our window-panes after the death of the fly. Many skin diseases are now known to be associated with the production of vegetable growths on the surface of our bodies.

1st. Dr. Salisbury points to the case of Mr. Dill, who got an attack

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[1] *American Journal of Medical Sciences.*

undistinguishable from measles while engaged in turning over a stack of musty straw, the odour from which persistently remained in his nostrils for long after he had ceased to handle the straw.

2nd. In an outbreak of measles at the military camp near Newark, Ohio, there was no trace of contagion ; the outbreak followed immediately on the melting of the snow while wet, which made the warm straw upon which the men slept in their tents musty.

3rd. Cases are mentioned by Mr. S——, in the persons of those employed in threshing wheat that had become heated.

These cases suggested to Dr. Salisbury the inquiry, whether camp measles was caused by musty straw. He examined the musty straw (wheat straw) to which had been attributed the cause of the measles ; he found certain fungi which are figured in his work, and to prove their identity with wheat-straw fungi he grew them in a box.

He then grew some fungi with which he inoculated himself, and produced the symptoms of measles with a partially developed rash ; a second inoculation failed to produce similar effects. Similar effects were produced by inoculation of his wife.

In a family where measles broke out, inoculation by the straw fungi, while giving measles of a modified form, prevented the occurrence of unmodified measles. These experiments are substantiated by other evidence, and are still further proved by the fact that measles is a disease of warm weather, or in other words, of that kind of weather which promotes the growth of the lowest forms of fungi and mouldiness.

Measles has also been shown to arise in connexion with musty linseed meal, by Dr. Henry Kennedy.[1]

3. *Small-pox.*—This being the only disease for which a prophylactic is known, it seems now scarcely necessary to discuss its prevention by vaccination ; but as some still deny the efficacy of vaccination, and as others even declare it to be injurious, it is necessary to say a few words in refutation of the views of the "anti-vaccination" party. Before the introduction of vaccination, the annual mortality from small-pox in England was at the rate of 3,000 in every million of the population, which with the present population would amount to 70,000 per annum. Dr. Farr,[2] writing of the late epidemic visitation of small-pox, says :—

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[1] *Dublin Journal of Medical Science.* Vol. xxxv. 1863. P. 60.

[2] Registrar-General of England. *Thirty-fourth Annual Report.* 1871. P. 219.

"This year (1871) is memorable for an epidemic of small-pox, which ravaged several parts of the kingdom in a way of which there has been no example since the year 1838, when the deaths by small-pox were 16,268. In the 24 consecutive years that ended in 1870, the annual deaths by this disease ranged from 1,320 in the year 1861, to 7,684 in 1864. The latter number they never exceeded until the year 1871, when the deaths by this single disease ran up to 23,126. The outbreak had all the suddenness of an explosion, for the deaths in the two previous years had been but 1,565 and 2,650."

Not only has vaccination diminished the number of cases of small-pox, but it has considerably diminished the mortality of those attacked, the mortality of those vaccinated being much lower than that of those unvaccinated. This is shown by the following Table taken from the Cork-street Hospital Report on Small-pox, already referred to:—

TABLE XIX.

Hospitals	Mortality per cent.		
	Vaccinated	Unvaccinated	General
Cork-street, - - -	10·8	71·8	21·6
Hardwicke, - - -	11·2	78·57	20·0
Cork, - - - -	5·5	58·0	22·5
London Small-pox, - -	14·9	66·2	18·8
Hampstead (London), - -	11·4	51·2	19·36
Homerton, - - -	5·9	37·7	16·3

TABLE XX.

	Discrete			Confluent			Malignant			Total		
	Total	Died	Per cent. Mortality	Total	Died	Per cent. Mortality	Total	Died	Per cent. Mortality	Total	Died	Per cent. Mortality
Vaccinated -	443	1	0·2	143	46	32·2	25	18	72	611	65	10·8
Unvaccinated -	17	6	35·1	94	67	71·2	24	24	100	135	97	71·8
Total -	460	7	1·6	237	113	47·6	49	42	85·7	746	162	21·6
Per cent. vaccinated in each class	96·3			60·4			51·9			81·8		

Of the vaccinated cases in the discrete variety, the mortality was practically nothing (0·2 per cent.), but one patient having died. In that case the patient had inflammation of the lungs, probably quite independent of the small-pox. Of the unvaccinated, however, in this class, 35·1 per cent. died. In the confluent cases the mortality among the vaccinated was 32·3 per cent., while among the unvaccinated it was as high as 71·2 per cent. In the malignant or purpuric variety, the mortality among the vaccinated was 71·8 per cent., or about the same as in the unvaccinated confluent variety; while in this variety *not one* unvaccinated case recovered. It may be merely a coincidence of percentage mortality, but it is a remarkable fact that in the cases under consideration vaccination reduced the mortality of confluent cases to that of discrete unvaccinated, and that of malignant to that of confluent unvaccinated cases. The proportion of vaccinated to unvaccinated cases in each variety is considerably greater, except in the malignant variety, where the proportions are nearly equal. The difference is most remarkable in the discrete variety, where the number of unvaccinated cases is very small; in other words, vaccination *prevented* a large number of these cases from being confluent.

The same story is told in the reports of all small-pox hospitals. Re-vaccination at proper intervals seems to be a complete preventive of small-pox, any cases where it has failed being always of a most peculiar character, as shown by the following statement:—

"Of re-vaccinated cases, properly so called, we had but four. Two of these were brothers, one of whom had been re-vaccinated twice, and the

other once ; both of them had purpuric small-pox, and both died, showing some extraordinary family peculiarity. Of the other two, one was doubtful and the other so remarkable that I will give the particulars. A male child, aged six weeks, who had not been vaccinated, was admitted : his mother had been successfully re-vaccinated about three weeks before; also his sister, aged thirteen. In order to secure proper attention to the baby, the sister was admitted to nurse him. This she did, sleeping with him at night, and carrying him in her arms all day, until his death, on the eighth day. Then the sister fell sick, and had the initiatory fever of the disease, and five modified vesicles appeared on her face and two on her chest ; she was confined to bed only for four days. I need scarcely point out that the exposure to contagion in this case was almost such as to preclude escape from infection, and I believe, but for the re-vaccination, this girl would have suffered terribly."[1]

That vaccination may in some few instances have done harm is certain ; unsuitable cases have been vaccinated, and lymph has been taken from improper sources, and probably has communicated the disease in rare instances ; but such occurrences are no arguments against the practice of vaccination, and should never be recognised by sanitary authorities as an excuse for being unvaccinated. The above-named unfortunate cases only point to the great care which should always be observed in choosing the cases for vaccination and in the collection of lymph. Injury from vaccination may be validly used as proof of the ignorance or carelessness of the operators, but not of the injurious nature of the operation.

(*f*.) Intermittent Fever.—Ague is so rare a disease in Ireland that it may be dismissed in a few words in a work for Irish sanitarians. The absence of ague from the bog districts of Ireland may be attributed to the powerful antiseptic action of peat, as otherwise all bogs would furnish the necessary conditions for the production of ague.

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[1] *Loc. cit.*

CHAPTER XIII.

Diseases Arising from Insufficient or Unwholesome Food.

Insufficient or Unwholesome Food lowers Vitality, and so predisposes to Disease—Dysentery, Diarrhœa, Purpura, and Scurvy arise from the inadequate supply of Food.

This subject, which in itself would occupy a considerable portion of any large work on the chemistry and physiology of food and dietetics, is so frequently alluded to in the chapters on "Zymotic Diseases" and on "Food" that but little is left beyond a general reference to these questions, in order to make our account of preventable diseases as complete as possible in the limited space at our disposal. In the chapter on Zymotic Diseases it has been shown how any causes which tend to lower vitality produce liability to disease; it is therefore unnecessary to show how unwholesome or insufficient food may, indirectly, subject persons to disease who, if properly fed, would have escaped. Under the head of "Diseases produced by Vicious Habits," it is shown how the use of alcohol produces ill-health, and we may here add that the excessive use of articles of food and drink, in themselves perfectly harmless, may be the means of producing disease.

The affections arising from the use of insufficient or unwholesome food may be included under the heads of dysentery, diarrhœa, purpura, or scurvy, to which may be added those diseased conditions resulting from the use of putrid or diseased food. We believe all these questions are sufficiently treated of under the head of Food, and need not be further referred to in the present chapter.

CHAPTER XIV.

Diseases usually termed Constitutional, which are Caused or Promoted by General Unhealthy Conditions.

Scrofula.—Phthisis and its connexion with Scrofula.—Pulmonary Consumption.—Relation of Consumption to Enteric Fever, Measles, and Scarlatina.—Diminution of Phthisis by Improved Sanitary Conditions.—Special localities favour Phthisis.—Relation of Phthisis to Impure Air.—Relation between Phthisis and Occupation.—Reduction of Phthisis in Army by Hygienic Measures.—Phthisis and Scrofula in Workhouses, Schools, and Public Institutions.

Scrofulous Affections.—These diseases may be included under the head of scrofula, for although it is possible that other diseases, now considered constitutional, may have local and preventable causes, yet scrofula and its allies, are the only so-called constitutional diseases which are at present known to be fairly within the control of sanitary measures. The diseases included under this head are—pulmonary consumption, tuberculosis, tabes, rickets, scrofulous glandular diseases, strumous or purulent ophthalmia, and the minor forms of strumous disease.

It would not be advisable, in the present state of our pathological knowledge, to treat scrofula and tuberculosis as synonymous terms ; but even admitting that in many cases the diseases may be far removed from one another, yet, from a sanitary point of view, they must be looked upon as having a close relationship.

Phthisis.—By far the most important disease of this class is phthisis or pulmonary consumption, which is much more under the control of sanitary measures than is generally believed by the public. There are a great many varieties of pulmonary consumption, originating in various ways, but no small proportion of them take their origin in zymotic disease. The frequency with which phthisis

follows enteric fever, measles, and scarlatina, is but too well known; and that a great many cases are also due to the prevalence of pythogenic pneumonia is pretty certain. Besides these modes of origin, the lowering of the general health of those living under insanitary conditions must tend to the development of consumption in those who have a hereditary predisposition to the disease. The general conditions which favour the spread of zymotic diseases also favour the spread of consumption, and any measures which diminish the one group of diseases also diminish the other. This is clearly shown by Table IX. already referred to, where the death-rate from phthisis has diminished, *pari passu*, with the other diseases. Besides the indirect effect of drainage works in diminishing phthisis, by the diminution of zymotics, they seem to act directly by drying the soil. This has been shown by many authorities, but especially by Dr. Buchanan, in his Report[1] on the "Distribution of Phthisis as affected by Dampness of Soil."

Dr. Buchanan concludes that "wetness of soil is a cause of phthisis to the population living upon it." "Phthisis has been greatly reduced in towns where the water of the soil has been artificially removed, and it has not been reduced in other towns where the soil had not been dried."

There is less phthisis among populations living on pervious than on impervious soils, and less among those living on high-lying than on low-lying pervious soils, and less among those living on high-lying than on low-lying impervious soils. There is a general agreement with regard to the prevalence of phthisis in places of similar geological or topographical conditions. It may be safely affirmed that the prevalence of this disease in certain families, commonly attributed to hereditary predisposition, might more correctly have been attributed to the circumstance of those families living for many generations upon a damp and impervious soil. The

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[1] *Privy Council Report.* No. 10. P. 109.

removal of certain members of phthisical families to other localities, at no great distance, seems to have saved them from the disease, all other conditions, except the locality, being the same.

Many cases of pulmonary consumption owe their origin to constant inhalation of impure air. Impurity of the air as a cause of pulmonary disease has been a subject of much discussion. It has not been shown, indeed, that any one particular atmospheric impurity is *the* cause of the pulmonary disease of those who constantly inhale impure air. One thing is certain, that persons following in-door occupations are more liable to the disease than those following out-door occupations. Thus, Dr. Cotton[1] shows that, in 1,000 cases of phthisis, 841 were in persons following in-door occupations, and but 159 in those following out-door occupations. Dr. Pollock[2] says:— "Confinement within doors seems to be in itself a predisposing cause of phthisis, which, judging by figures, is one of the most powerful."

Among 3,214 men at the hospitals, more than one-half had followed in-door occupations; and the 2,413 women may be said to have been almost all so engaged. Dr. Pollock gives the following Table of occupations of phthisical patients, taken from the Report of the Hospital for Consumption and Diseases of the Chest, Brompton:—

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[1] *On Consumption, its Nature, Symptoms, and Treatment.* By R. P. Cotton, M.D. 1858. P. 69.

[2] *Elements of Prognosis in Consumption.* By J. E. Pollock, M.D. London. 1865. P. 366.

TABLE XXI.—*Showing the Occupations of* 5,627 *Persons, of both Sexes, affected by Phthisis.*

Males		Males	
Bakers,	89	Railway Men,	38
Bookbinders,	17	Sailors and Watermen,	74
Bricklayers,	109	Servants,	285
Butchers,	3	Shoemakers,	171
Carpenters,	295	Soldiers and Police,	103
Clerks and Shopmen,	394	Smiths,	89
Coachmen,	211	Teachers,	42
Gardeners,	82	Tailors,	145
Labourers,	539	Weavers,	11
Mechanics,	176	At Home,	63
Painters,	105	Various,	49
Printers,	103		
Publicans,	46	Total,	3,214
Females		**Females**	
Servants,	984	Other Trades,	150
Domestics,	447	At Home,	278
Milliners,	397		
Laundresses,	77		
Governesses, etc.,	80	Total,	2,413

From this Table it is apparent that phthisis prevails in exact proportion to the degree of confinement of the sufferers.

The influence of closeness of air in the production of phthisis is so great that Dr. MacCormac, of Belfast, has supported the view that this is *the* cause of phthisis, and has further argued that the inhalation of air which has already been respired is the sole cause of the disease, and further, that the noxious element in the respired air is the carbon of the carbonic acid contained therein.[1] While we do not go quite so far as Dr. MacCormac, we admit that the most potent single cause of phthisis is the constant inhalation of impure air.

[1] *Consumption and the Breath Rebreathed.* By Henry MacCormac, M.D. London: Longmans. 1872.

By sanitary measures, chiefly those of improved ventilation and increased cubic space, the mortality from this disease in the army has been reduced to one-half in all, and to one-third in some corps. In considering this question it is not fair to include as consumption those pulmonary diseases which are the result of special occupations, such as those arising from dust or particles of materials used in trades, as the so-called miners' and knife-grinders' diseases.

SCROFULA.—The prevalence of other forms of scrofulous disease can be easily shown to depend on insanitary conditions, especially impurity of air, unwholesomeness or insufficiency of food. The greater prevalence of scrofula among the children of the poor, as compared with those of the rich, can be explained only upon this supposition. The prevalence of scrofula in large establishments, especially workhouse and charity schools, was in former days so constant that it was looked upon as an almost inevitable disease in such institutions, and unfortunately was always attributed to the scrofulous diathesis of the person before admission. The improved sanitary conditions, now so generally enforced in public establishments, have shown that scrofulous disease in such communities is not only not an inevitable necessity, but that children admitted with scrofulous affections may have their unhealthiness removed by the mere transfer to well-regulated public establishments. A great deal of scrofulous disease among children in public institutions may be attributed to the rigidness of the rules. Thus children of varying ages and different degrees of mental and bodily vigour are constantly classed together with regard to diet, rest, exercise, or study. From some too much is expected, and from others possibly too little. As the majority of sanitary authorities in Ireland have to deal with the management of workhouses and workhouse schools, they, together with their officers, should be especially aware of the fact that improper classification in the above-mentioned important matters will almost certainly give rise to scrofulous diseases among the children under their charge, and

ultimately prevent these children from being returned to the commonwealth as healthy adults, rendering them a burden and a loss instead of an advantage and source of wealth to the nation.

It is unnecessary to treat here particularly of the various other diseases mentioned in the beginning of this chapter. The remedies for them are obvious.

CHAPTER XV.

Artisans' Diseases.

Three Classes ; 1. Those arising from Constrained Position ; 2. Those arising from Mechanical Irritants ; 3. Those arising from the Introduction of Poisonous Materials into the System—Preventives of each Class of Affections.

The majority of artisans' diseases depend not so much upon the special trade of the artisan as upon the circumstances under which his trade is exercised. It has already been shown, in the chapter on Constitutional Diseases, how many diseases usually termed constitutional may arise from following occupations exercised under unhealthy conditions. Besides diseases so engendered, there are others which specially attack those employed in particular trades. They may be classified as follows :—

1st. Those owing to the constrained position in which the trade is exercised.

2nd. Those arising from mechanical irritants given off from the materials employed in manufactures.

3rd. Those arising from the effects of poisons used in manufactures.

It will be impossible to do more than enumerate some of the diseases belonging to each class, and refer to the means of prevention which, in most instances, are sufficiently obvious.

Under the first class may be placed the compressed chests, and, consequently, injured lungs of shoemakers, resulting from the pressure of the "last" against the lower part of the chest. Writers' Palsy also belongs to this class, where the constant use of a particular group of muscles of the forearm and hand leads to an amount of spasmodic irritability which finally compels the patient to relinquish his trade or learn to write with his left hand. Even the constrained position in which school boys and girls are taught to write not unfrequently gives rise to curved spines and distorted shoulders.

In the second class are included all those diseases which arise from the inhalation of dust. The constant inhalation of irritating particles of the materials with which the artisan has to work, produces, in most instances, chronic diseases of the bronchial tubes, which are analogous in their symptoms and results to bronchitis and pulmonary consumption. In fact, until recently, these diseases were all included under the term pulmonary consumption.

The persons chiefly affected by diseases of this class are: coal-miners, knife-grinders, flax-dressers and hacklers, and stone-cutters; besides, in a less degree, workers in wool, cotton, hair, shoddy, etc.

The sufferings of the knife-grinders are well known; and great attention has been paid to devising means for the prevention of the knife-grinders' disease or "rot," as it is sometimes termed. These consist in providing respirators, or masks, to intercept the particles of metal; the arrangement of magnets, in connexion with either the respirators or the grindstones; and the ventilation of the workshops in such a way as to produce currents of air in the neighbourhood of the grinding machinery, so as to carry off the dust as soon as it is formed. The substitution of *wet* for *dry grinding*, under all circumstances, has been proposed, but is found to be inconsistent with the requirements of the trade.

In the other trades in which dust is produced the workers can be protected only by the provision of efficient ventilation and the employment of respirators. In practice it is found almost impossible to induce the workers to use respirators, or any other means productive of personal inconvenience. We are indebted to Dr. MacCormac, of Belfast, for valuable information with respect to the effects of the dust produced in the flax mills upon the health of the flax-dressers and hacklers of Belfast. It would be impossible here to give details of all the sad effects produced by the inhalation of dust by artisans.

To the third class belong diseases, few in number, but one, at least, is of very frequent occurrence. Lead, arsenic, and

mercury, may be said to be the only mineral, and tobacco the only organic, substances which produce poisonous effects upon artisans. Lead poisoning arises in plumbers, printers, and painters, especially in the last. Lead poisoning may, to a great extent, be prevented by extreme cleanliness on the part of the operatives. Painters who change their clothing frequently and who wash their hands constantly, especially before eating, seldom suffer from lead poisoning. The same is true, to a great extent, of printers and plumbers.

Arsenical poisoning is much less frequent than lead poisoning. Arsenic is not employed in many trades, but is used for the manufacture of pigments, especially the brilliant green of wall papers. The minor effects of arsenical poisoning, or, more correctly, arsenical irritation, are common to paper-hangers, or manufacturers of room papers. The symptoms of general arsenical poisoning seldom arise in any trade except shot-making, where the disease might easily be avoided under proper precautions. Tobacco poisoning is not unfrequently met with in tobacco spinners and snuff makers. Mercurial poisoning is met with in looking-glass manufacturers, cleaners of plate, and water gilders. The use of mercury in these trades is, however, diminishing; new and improved modes of manufacture are gradually displacing the use of this dangerous metal. We must refer our readers to Dr. Mapother's valuable papers and lectures on "Artisans' Diseases," for further information upon all these points, but especially with regard to the use of mercury in manufactures.

Besides these more specific forms of disease, there are trades in which the constant exposure to great extremes of temperature, to variations of atmospheric pressure (as workers in diving-bells and *caissons*), gives rise to various diseased conditions. And we would again point out, that no matter how innocuous a trade may be in itself, it may become highly deleterious to health when exercised under unhealthy conditions.

CHAPTER XVI.

Diseases caused by Vicious Habits.

Alcoholism.—Relation between Alcoholism, Disease, and Death-rate.—Secondary causes of Death from Alcoholism.—Relation between Excessive Use of Alcohol and Insanitary Conditions.—Venereal Diseases.—Promoting Causes are Psychical.—They are also promoted by Overcrowded Dwellings, want of Education, and Immoral Publications.—Contagious Diseases Acts.—Benefit from Contagious Diseases Acts.

The affections caused by vicious habits are alcoholism and venereal diseases; diseases resulting from the excessive indulgence in any appetite might be included.

Alcoholism.—It is comparatively seldom that death is the direct result of the excessive indulgence in alcoholic fluid, but nevertheless a very large and unknown amount of disease is caused by the excessive use of alcohol.

The statistics of intemperance show that it is certainly on the increase, but nevertheless the number of deaths under the head of alcoholism is diminishing. The statistics of intemperance are, for the most part, extremely unreliable, the limited number contained in the police reports being alone authentic. Although the number of deaths from alcoholism is small according to the returns of the Registrar-General, yet it is perfectly certain that in each class of disease a considerable number of cases have their origin in alcoholic excess. Many deaths from renal, hepatic, gastric, and nervous diseases, might fairly be returned as alcoholic in origin.

The greater prevalence of epidemics of zymotic diseases among the lower stratum of society is, to a certain extent, attributable to the intemperance of this class, and consequent reduction of their power to resist disease. This is not, however, so much the case as many suppose, for the promoting causes of zymotic disease tend to produce intemperance in many ways. The insanitary conditions under which the

working classes live tend to lower vitality; this depression can be resisted for the time only by the use of stimulants; the most ready stimulant for the working man is alcohol; he therefore employs it, finds it produces the desired effects, and goes on using it; the quantity required to produce the stimulating effect gradually increases, and finally intemperate habits are engendered in a man who, if he had lived under proper sanitary conditions, would perhaps never have been induced to make free use of alcohol. Drunkenness again, by producing poverty and carelessness, further promotes insanitary conditions; thus drunkenness and insanitary conditions react on one another, each producing the other. Comfortable dwellings will do more to promote sobriety than any amount of legislation or teetotal agitation.

Another source of excessive alcoholic stimulation is *overwork*, which by its depressing effects on the system leads to a demand for stimulation, with a view of getting more work out of an exhausted frame which would have been properly renovated by rest. This is a more common source of excessive use of alcohol among the upper than the lower classes of society, and should not be lost sight of by sanitarians.

Various laws have, from time to time, been enacted with a view of diminishing drunkenness, but mainly for the purpose of increasing the revenue of the State; from the former point of view these measures have been an almost complete failure, from the latter they have been a complete success.

Venereal Diseases.—All diseases resulting from impure sexual intercourse must, for sanitary purposes, be classed together.

The promoting causes of venereal diseases are almost altogether of a psychical nature, and have their origin in immoral causes, but many of these have their primary origin in physical conditions. Thus immorality is promoted by overcrowded dwellings, and the too close contact of the sexes in the wretched homes of the working classes, in many of which decency is totally disregarded. The want of proper

education, and the reading of immoral publications and quack advertisements, have much to do with the development of the scandal, excesses, and irregularities which tend to venereal diseases.

The prevention of venereal disease must, therefore, to a great extent, depend on the promotion of education and moral training. Venereal disease has, however, grown into such a great evil that the Legislature has interfered with a view of protecting our soldiers from its injurious effects; and, in passing the Contagious Diseases Acts, has laid down principles which, if extended to the population at large, must tend much to the prevention of venereal disease.

The Contagious Diseases Acts[1] have produced a decided diminution of venereal disease in places where the Acts have been enforced. This is shown by the statistics of venereal disease among the military stationed in these towns. The contrast between the prevalence of venereal diseases at stations under and not under the Act, is shown in the following Tables, taken from Dr. Parkes' work.[2] The principal Act was first enforced in October, 1866.

Table XXII.

Admissions of Primary Venereal Sores per 1,000 of strength.

Stations under the Act.					
	1867	1868	1869	1870	1871
Plymouth, - -	76	66	74	58	50
Portsmouth, -	116	86	62	51	41
Chatham, - -	71	63	41	47	65
Woolwich, - -	88	46	52	43	58
Aldershot, -	81	77	63	67	65
Dover, - -	132	111	80	30	24

[1] The Contagious Diseases Acts are three in number, viz. :—29 & 30 Vic. cap. 35 ; 31 & 32 Vic. cap. 80 ; and 32 & 33 Vic. cap. 96. The only parts of Ireland to which these Acts apply are—1. The Curragh Camp and its immediate neighbourhood; 2. The Municipal Borough of Cork ; and 3. The town of Queenstown.

[2] *Manual of Hygiene.* Fourth Edition. P. 466 and *seq.*

TABLE XXIII.

Admissions of Primary Venereal Sores per 1,000 of strength.

Stations not under the Act.					
	1867	1868	1869	1870	1871
London, - -	163	148	144	160	190
Sheffield, - -	163	107	146	77	126
Manchester, -	177	115	160	92	70
Dublin, - -	129	139	180	128	117
Isle of Wight, -	59	103	129	64	66
Belfast, - -	89	56	52	43	61

Thus there has been a decided decrease in primary venereal sores since the enforcing of the Act at stations under the Act, and the contrast shown in the Table between the protected and unprotected stations is remarkable.

The following Table, quoted by Dr. Parkes from Dr. Balfour's figures, has been compiled from observations at stations under the Act, with a mean strength of 51,400 men, and stations not under the Act, with a mean strength of 19,953 men.

TABLE XXIV.—*Admissions per 1,000 strength.*

		Primary Sores	Gonorrhœa
Stations under the Act -	1871	50·6	116·9
	1872	53·3	105·1
Stations not under the Act -	1871	93·4	107·4
	1872	123·2	105·9

Gonorrhœa has not been materially interfered with by the Acts, in consequence of the want of hospital accommodation.

Taking all years since the Act first came into force (1865 to 1872 inclusive), the admissions per 1,000 of strength were—

	Primary Sores	Gonorrhœa
All Stations not under the Act, Mean Strength 32,528 men	103·1	111·9
Stations under the Act, Mean Strength 30,765	62·8	115·0

All this has been done without any material interference with the so-called "liberty of the subject," without any increase in prostitution or promotion of immorality, while there has been a substantial diminution of venereal diseases, and many prostitutes have been reformed and sent home to their friends.

Why should not the benefit of the Contagious Diseases Acts be extended to the civil population, it having been proved by experience that these Acts are efficient for the diminution of venereal disease? Legislation for the prevention of venereal diseases, although tending to increase the safety of the people, cannot be described as protection for prostitution. Prostitution and the keeping of houses of ill-fame are not in any way legalised by the enforcement of the Contagious Diseases Acts, although there is a popular belief that such is the fact. The case is almost entirely parallel to that of legislation with regard to drunkenness. Drunkenness and the promotion of drunkenness in public-houses are treated by the State as crimes; so is prostitution. A drunkard is prevented by the State from inflicting physical injury upon himself or his neighbours when drunk, by his arrest and confinement; but such taking care of a drunkard is not considered by any one a protection and prevention of alcoholic excess. So the prostitute, when dangerous from being affected by venereal disease, is prevented from inflicting physical injury on herself or others (or the children of herself or others, for the disease is hereditary) by arrest and detention until harmless; but in neither case does the State protect or approve of the moral sin of alcoholic excess, or of illicit sexual intercourse.

CHAPTER XVII.

FOOD.

Quantity of Food; Dietary.—Sufficiency of Food.—Effect of Age, Weight, and Sex.—*Quality* of Food.—Examination of Meat: Beef, Mutton, Pork, Sausages.—Poultry.—Fish.—Vegetables and Fruit, Preserved Fruits.—Sugar, Bon-bons.—Flour.—Bread.—Cows' Milk, Composition of Milk.—Butter.—Tea.—Coffee.—Cocoa.—Chocolate.—Vinegar.—Mustard.—Cayenne Pepper.—Cheese.—Isinglass.—Arrowroot (West Indian or Maranta.)

In this work it would obviously be impossible to discuss in the requisite detail the many important and interesting questions affecting the relative values of the different kinds of food consumed by the population of this country; hence we shall deal only with the practical points which will be most likely to engage the attention of the Medical Officer of Health. The sanitary questions connected with food supply may be broadly divided into those affecting (1) the *sufficiency* and (2) the *quality* of the nutriment.

1. *Quantity of Food; Dietary.*—The sufficiency or otherwise of a particular diet to support life, and to maintain the human adult in healthy and vigorous condition, can now be determined within certain limits, owing to the valuable researches of Playfair, Pettenkofer and Voit, Haughton, Frankland, Edward Smith, and others. These distinguished observers have determined, by large numbers of carefully-conducted and varied experiments, the average food requirements for different states of muscular and even intellectual activity. The results, though of necessity only approximately correct, enable us to form a fair estimate of the minimal supply requisite for the average man as regards the two great classes of nutriment—namely, the nitrogenised and the carbonaceous, or the so-called "flesh-forming" and "heat and fat producing" foods. As the nutritive values of these are dependent respectively on the proportions of nitrogen and of carbon they contain in an available form, the daily

requirements may be stated in grains of nitrogen and of carbon. According to Dr. Edward Smith, an average man, not actively employed, needs for the maintenance of his health 200 grains of nitrogen and 4,300 of carbon daily, while a woman requires about one-tenth less of each. When engaged in work, at least one-third more nitrogen and the same proportion of carbon must be added to the food.

In order to make use of these data for the purpose of determining the question of sufficiency or insufficiency of food, or for the construction of dietary, we require to know the proportion of nitrogen and of carbon in the principal articles of human consumption. The following Table, which we extract from Dr. Letheby's "Lectures on Food" (p. 124), gives the necessary information, and states the weights of the several articles containing 200 grains of nitrogen, and the amount of carbon also present:—

Table XXV.

Amounts of Food yielding 200 *grains of Nitrogen, or* 2·67 *ozs. of Plastic Matter, necessary for a Man's Diet.*

Description of Food	Ozs.	Carbon in it. Grs.	
Skim-cheese, - - - -	6·6	778	Carbon deficient
White Fish, - - - -	16·4	836	
Lean Meat, - - - -	15·6	951	
Skim-milk, - - - -	74·2	2,049	
Peas, - - - - -	11·2	2,164	
New-milk, - - - -	72·4	2,683	
Oatmeal, - - - -	23·6	4,184	
Wheat-flour, - - - -	27·5	4,647	Carbon in excess
Baker's Bread, - - - -	36·7	4,532	
Indian-meal, - - - -	26·8	5,046	
Rye-meal, - - - -	37·1	6,265	
Barley-meal, - - - -	47·1	7,997	
Rice, - - - - -	47·1	8,053	
Bacon, - - - - -	33·7	12,617	
Potatoes, [1] - - - -	140·0	8,000	

[1] This food we have added to the Table.

The effect of age and weight upon the determination of the sufficiency of food is very considerable, as will be easily seen by reference to the following Table, calculated from Dr. Edward Smith's special determination of the influence of age. In this Table the daily requirements are given in grains of nitrogen and of carbon *for each pound weight* of the body:—

	Nitrogen per lb. of body	Carbon per lb. of body
Adult man - -	1·25 grains[1]	28 grains
16 years of age -	2·16 ,,	34 ,,
10 ,, ,, -	2·81 ,,	48 ,,
Infancy - -	6·78 ,,	70 ,,

If, therefore, the age, weight, and sex of an individual, are known, the medical officer can easily determine, with the aid of the above information, whether or not a given diet is sufficient to maintain the person in health.

In constructing a dietary, however, it must be remembered that the food supply should be varied as much as possible, if not in kind, at least in mode of cooking, since sameness of diet is apt to lead to disgust and to the consumption of an insufficient amount of food. Moreover, the digestibility of the food and the peculiarity of the individual must be taken into account; the former more particularly in considering the question of sufficiency, as it would be obviously absurd to expect hard, tough meat to afford as much nutriment as that which is tender, especially if the consumer's power of mastication happens to be feeble.

2. *Quality of Food.*—In order to distinguish wholesome from unwholesome food, it is often sufficient for the medical officer to ascertain whether a given article presents the characters which serve for its distinction when in a sound or

[1] This value is probably somewhat too low, as the Rev. Professor Haughton's results prove that this proportion is excreted daily in the form of urea alone.

unadulterated condition. The determination of the precise cause of unsoundness—say, of meat—is often an exceedingly difficult matter, though the condition can be easily ascertained by applying certain *criteria*, with which we shall provide the reader. Similarly the accurate *identification* of impurities or adulterants is the work of the chemist and microscopist; but it is often possible by very simple means and without the possession of elaborate apparatus to find out whether or not a particular article of commerce is in a pure or an impure condition, and in many cases to name the impurity or adulterant *probably* present. Our aim now is to bring together as much of this class of information as happens to be available at present; but for special instructions in the detection of adulteration, the reader is referred to the last edition of Dr. Hassall's large and useful work.[1]

In carrying out our plan so far as food-substances liable to adulteration are concerned, we found it inexpedient to do more than to name the impurities and adulterants which have hitherto been detected in the various bodies, and to state as briefly as possible the distinguishing characters of each genuine article. This necessary course will be pursued in the following sections, in which we shall deal with the chief articles of food, excluding most of the condimental foods on one hand, and alcoholic liquids on the other.

MEAT.—Much misconception exists in the public mind as to what constitutes unwholesome meat, it being commonly held that the meat of diseased animals is alone unwholesome, whereas, in truth, the possession of poisonous properties can be more distinctly traced to the putrescent meat of healthy animals than to the fresh meat of diseased animals, unless when the flesh happens to be infested by dangerous parasites. As the meat of diseased animals usually decomposes rapidly,

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[1] *Adulterations Detected.* By Arthur Hill Hassall, M.D. London: Longmans.

it is not improbable that in many of the recorded cases of supposed meat-poisoning, the effects attributed to the virus of disease were really due to the putrescent condition of the food. According to Dr. Taylor:—

"The flesh of the most healthy animal is rendered unfit for food when it has passed into a putrescent state. It is not merely unwholesome, but highly irritant, causing rapidly vomiting, purging, pain, and other symptoms of a severe kind. Fortunately, these symptoms lead at once to the expulsion of the noxious food from the body, and the person then recovers; the young, the old, and the infirm, may, however, be so prostrated by vomiting and purging, that they may sink from exhaustion. Animal matter in a state of partial decay, or in the transition stage of putrefaction, must be regarded as of a poisonous nature. Much of the cheap butcher's meat sold to the poor is in a state of decay, and is quite unfit for human food. . . . In January, 1851, the family of a surgeon near London were all affected with symptoms resembling irritant poisoning after having partaken of a hare which had been stewed in a clean earthen vessel. The surgeon informed me that on the second day his wife was seized with vomiting and purging, giddiness, heat in the throat, and general numbness, with inflamed eyes. Other members of the family vomited, and in the course of a few days the symptoms disappeared. I examined the vomited matter, and found it to consist of portions of the hare partially digested, but in a state of putrefaction; so that there was abundant evidence of sulphuretted hydrogen in the liquid. There was no mineral poison of any kind, although the symptoms, it will be observed, were rather like those occasioned by arsenic. It had been remarked by this family that a silver spoon which had been used in serving out this unwholesome food was turned of a brown colour, no doubt from the chemical action of the sulphuretted hydrogen; and this may be taken as a good domestic test of the putrefied condition of such food. Nature generally applies an

appropriate remedy in the fact that the food itself produces copious vomiting and purging."

The meat of over-driven animals has been known to produce poisonous effects.

Good and wholesome *beef* or *mutton* should exhibit the following easily-observed characters :—

1. It ought to be of a pale, slightly brownish, red colour, neither of a pale pink on the one hand nor of a deep purple hue on the other. If pink, disease is indicated; and if purple, the animal has, probably, not been slaughtered, but has died with the blood in it, or has suffered from acute fever.

2. It should have a marbled appearance, from the ramifications of little veins of fat among the muscles.

3. It should be firm and elastic to the touch, and should scarcely moisten the fingers. Bad meat is usually wet, sodden, and flabby, with the fat looking like jelly or wet parchment.

4. It should have little or no odour, and not disagreeable; for diseased meat has a sickly, cadaverous smell. Any disagreeable odour is most easily detected when the meat is chopped up and drenched with warm water.

5. It should not shrink or waste much in cooking.

6. It should not become very soft and wet on standing for a day or so, but should, on the contrary, dry on the surface.—(*Letheby*).

If the liver of the animal can be obtained, it should be carefully examined for *distomata* (flukes). These are flat worms, like flounders in miniature, of the size of the nail of the little finger.

Pork, if unsalted, should present the characters above stated; but the colour of the meat, if sound, is of a very pale red tint. When infested by the dangerous parasite, *Trichina Spiralis*,[1] the meat is usually of a dark colour.

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[1] For drawing of this parasite, see *Taylor's Medical Jurisprudence*. Large edition. Pp. 278 and 279.

Unfortunately, the animal itself can scarcely be detected by the unaided eye, but when the muscles are examined, near to the tendons especially, with a very moderate magnifying power, the little capsule containing the worm is easily distinguished. On the other hand, the *cysticercus* or measle, whose little sac is often as large as a hempseed, can be easily seen, particularly in the psoas muscles.

Sausages are liable to partial decomposition, and then become poisonous, from whatever kind of meat they may have been prepared. Good sausage meat should be firm, not moist, gelatinous, and vesicular. It should be free from disagreeable smell and taste, and from acidity.

POULTRY.—It is unnecessary to say more under this head than to point out that this class of meat should fulfil the conditions 4, 5, and 6, given above.

FISH should be used only when fresh, and this condition can be easily ascertained. Fresh fish is free from offensive smell, and the flesh is not soft or gelatinous. It may be well to mention that fresh salmon or trout should not only have the well-known pink-coloured flesh, but when the finger is drawn quickly and firmly *across* the fish, the depression so caused ought to fill up quickly, and a corresponding elevation or ridge soon appear.

Sea fish is not tested in this way, but the rigidity of the fish is sufficient to indicate its fresh condition.

The bright red colour of fish gills is a sign of very little importance, as the gills are often artificially tinted.

VEGETABLES AND FRUIT.—Under this head it is only necessary to say that these articles of food should be invariably used in a fresh and ripe condition.

It is, however, often a matter of importance to be able to distinguish poisonous mushrooms from those that are edible. It may be generally stated that mushrooms which have a disagreeable styptic taste and a pungent smell should always be rejected. The edible mushroom used in this country has a white top and *pink* gills; as the fungus grows the gills

change to a brownish or even nearly black colour. Mushrooms found in open pastures are almost always safe; those found near trees should be avoided.

Preserved Fruits, *etc.*, should not be eaten if mouldy or in a state of decomposition, as evidenced by effervescence or slight frothing, and an unusually acid taste. All preserves, if made in copper vessels, should be tested for copper by stirring a thick bright steel needle for some time through the preserve, mixed with a little warm water. If, after stirring and standing for an hour or so, the needle, on removal, and rinsing with water, is free from any of the well-known reddish deposit of metallic copper, the preserve cannot contain any sensible quantity of the poisonous metal. The same test should always be applied to pickles.

SUGAR.—*Adulterations and Impurities.*—Fine white loaf sugar is rarely adulterated, but coloured sugars sometimes contain chalk, sand, clay, starch sugar, flour, dextrine, plaster of Paris. As impurities, fragments of cane, molasses, vegetable albumen, and sugar mites or *Acari.*

Good sugar should be free from the least bitter taste, and ought to dissolve completely in water. Loaf sugar should give a perfectly clear and colourless solution; brown sugar, a clear but coloured liquid. If *Acari* are present, they float on the syrup, and appear as small specks, which can be easily removed for microscopic examination.

Bon-bons, unless when mixed with harmless starch or injurious white or coloured mineral powders, produce clear solutions when dissolved in water. If any insoluble residue be left, the deposit should be allowed to settle, the liquid poured carefully off, and the powder collected, dried, and heated on platinum foil. If white, and wholly combustible, and rendered brown or blue on treatment with a very dilute tincture of iodine, it consists of starch. Chromate of lead (yellow), arsenite of copper (green), china clay and gypsum (white), and most other injurious mineral pigments, give insoluble and fixed powders. Sulphide of mercury or vermilion,

though volatile when heated on platinum foil, is easily recognised by affording a heavy red powder on treatment of the sweets with water, and this powder, when heated in a test tube with "bread soda," yields the well-known globules of metallic "mercury."

FLOUR (Wheaten).—*Adulterants and Impurities.*—Rice, barley, dari, bean flour, "cones" flour, Indian corn, rye, potatoes, alum, gypsum, clay, darnel, ergot, flour mites (Acari).

Good flour should not be acid or musty; but ought to have a pleasant flavour. When a small quantity is moistened with water, and examined under the microscope, should this instrument happen to be available, no *mites* ought to appear.[1] When burnt completely, it should not leave more than 2 per cent. of ash, and this when moistened with water ought not to afford an alkaline reaction to test paper.

The ash of leguminous plants is always alkaline. As we shall frequently have to refer to determinations of ash left after complete combustion, we may now describe the simple plan of operating. Take a piece of stout platinum foil, free from holes, and about two inches square, turn up the edges, so as to make a little tray, now place this in one pan of a balance or scales, and carefully counterpoise it; then put the 100 centigramme weight (1 gramme) into the other pan, and weigh off into the platinum tray 100 centigrammes of the flour. Next remove the little tray, and support it over a spirit or Bunsen gas flame, and carefully burn the flour away until a white ash remains; when the platinum tray has cooled down, wipe the under side clean, taking care not to spill the ash, and then replace in the scales. The residue should not weigh more than two centigrammes.

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[1] At the same time the character of the starch may be examined, and the forms of the granules compared with the plates in *Hassall's Adulterations Detected*, or with known specimens of wheaten, potato, rice, and other starches.

Flour containing potato starch is easily gelatinised by an aqueous solution containing 2 per cent. of caustic potash. In applying this potash test it is well to observe whether any unpleasant fishy smell is produced, even on warming, since if the flour contains the poisonous *ergot*, this peculiar odour is easily developed. The detection of ergot in flour can also be effected by shaking it up with a mixture of one part of chloroform and six parts of strong spirit of wine. The ergot present in the flour will float on the liquid, and form a brown scum.

BREAD.—*Adulterants.*—Water, rice, potato, and other starches, salt, alum, bone dust, clay, carbonate of magnesium, chalk, gypsum, and sulphate of copper; or it may be impure from bad flour.

Good bread is sweet and agreeable to the taste. It does not present a mouldy appearance, and ought not to give a thick liquid when steeped in water. If bread becomes soft and sodden on standing, it is probably adulterated with rice. When a piece containing much alum is dipped in a very weak solution of the colouring matter of logwood, the bread is quickly dyed of a purple tint; but the test is, at best, uncertain in its action, and therefore unreliable.

Good bread ought not to contain more than 40 per cent. of water, and should not leave more than 1½ per cent. of ash when burned on platinum foil.

When the ash is heated with strong nitric acid, the liquid slightly diluted, then filtered, and the filtrate rendered alkaline by ammonia, a blue tint ought not to be developed. If copper be present, a blue colour is immediately produced.

The percentage of water is determined by taking a known weight (a round cut from the middle of the loaf) and carefully drying it for 4 hours in an oven, at a temperature a few degrees beyond that of boiling water. The loss in weight, after drying, measures the water in the bread.

The following is the best process for testing bread for alum, or rather for alumina, its chief constituent, and is due to Mr. Crookes :—

"The bread, of which at least 30 grammes should be taken, is first to be incinerated in a platinum or porcelain dish, until all volatile organic matter has been expelled, and a black carbonaceous ash remains. The temperature must not be raised much beyond the point necessary to effect this. Powder the coal thus obtained, and add about 30 drops of oil of vitriol, and heat until vapours begin to rise; when sufficiently cool, add water and boil for ten minutes. Filter and evaporate the filtrate until the fumes of sulphuric acid begin to be evolved, when about 70 centigrammes of metallic tin, and an excess of nitric acid must be added, together with water, drop by drop, until action between the acid and metal commences. When all the tin is oxidised, add water and filter. Evaporate the filtrate until fumes of sulphuric acid are again visible, when more water must be added, and the liquid again filtered if necessary. To the clear solution now add tartaric acid, then ammonia in excess, and sulphide of ammonium. Evaporate the liquid, containing the precipitate suspended in it, in a dish until all the smell of sulphide of ammonium has disappeared. Filter, evaporate to dryness, and ignite to get rid of the organic matter. Powder the black ash, boil it in moderately strong hydrochloric acid, filter, add a crystal of chlorate of potash, and boil for a minute. Now add chloride of ammonium and ammonia, and boil for 5 minutes. If, at the end of that time, any precipitate is observed, it will be alumina."

COWS' MILK.—*Adulterations.*—The chief is, undoubtedly, water; but skim-milk, annatto, brains, chalk, tragacanth and other gums, sugar, salt, decoction of white carrots, starch, and turmeric, are stated to be occasionally used. It is certain, however, that the frauds most commonly practised are (*a*) addition of water, and (*b*) subtraction of cream.

Good Milk should be free from acidity, and when allowed to stand in a deep vessel, for an hour, ought not to deposit any solid matter. It should afford, at least, ten per cent. of cream when allowed to stand for twelve hours in Sir Joseph Banks' milk test-tube. This simple piece of apparatus consists of a large test-tube divided into 100 parts from above downwards; but 30 of these divisions only are marked. In order to use the test, milk, which has not yet thrown up a sensible quantity of cream, is poured into the tube until the latter is filled to the 0 or zero division. On standing, the cream rises, and the depth of the stratum,

formed during a given time, is easily measured by the scale engraved on the glass, since the yellowish colour of the cream renders the layer easily distinguishable. Of all "rough-and-ready" tests this one is least open to objection, *if sufficient time (twelve hours) be given for the separation of the cream.* Milk yielding 10 per cent. of cream cannot be considered bad. The specific gravity test, or common "lactometer," is utterly worthless and misleading as a means of ascertaining the quality of milk.

Again, good milk should yield about 12 per cent. of solid matter dried at 100° C., as numerous analyses, made by ourselves and others, have proved that good average cow's milk contains in a hundred parts—

Water, - - - - -	87·50
Casein, - - - - -	4·21
Fat, - - - - -	3·30
Sugar, - - - - -	4·35
Mineral matter, - - - -	·64
	100·00

A sample having this composition would afford on evaporation to dryness 12·5 per cent. of residue. This old and well-known "evaporation test" is easily applied in the following way:—Take a thin glass capsule, similar to that used in the evaporation of water (see page 230), and accurately counterpoise it in the balance. Now weigh off 10 grammes of the well-mixed sample of milk, then place the dish on the water-bath, and evaporate as rapidly as possible, taking care to occasionally move about the capsule in order to distribute the milk over the inner surface, and so facilitate evaporation. When apparently dry, continue the heating on the water-bath for an hour longer, and then cautiously break up any crusts with a sharp-pointed penknife, and dry again for half an hour; but this time, if possible, in an oven heated a few degrees beyond the temperature of boiling water. The vessel is then allowed to cool under a desiccator, as in the

estimation of a water residue, and the capsule, with its contents, weighed. The excess of weight over the counterpoise of the capsule, of course, gives the proportion of dry residue in 10 grammes of the sample. This weight ought to be 1·25 grammes.

If we desire to determine the fat in the residue, the following treatment must be pursued:—Reduce the contents of the capsule to as fine a state of division as possible without removing a particle from the vessel,[1] and pour over the powder a quantity of ether; stir well, and allow the ether to stand upon the residue for half an hour, taking care to cover the vessel meanwhile; then pour off the ether without losing any of the powder, and repeat the treatment with fresh ether. The process is continued until the ether treatment has been applied five times; then dry the residue, which ought to be now almost wholly free from fat, at 100 C., and again weigh. The loss in weight represents the fat dissolved out by the ether. The determination of the sugar and casein cannot be so easily effected, and, indeed, should not be attempted by anyone little skilled in chemical manipulations. However, we shall content ourselves by referring the reader who may desire information on these points to Dr. Hassall's work, already quoted.

We hold the opinion that a sample of milk which gives 10 per cent. of cream in Banks' tube, and 12·0 per cent. of dry residue capable of yielding 3·3 per cent. of fat, is to be regarded as certainly good milk, and that a sample falling below these standards to any very sensible extent is to be considered inferior milk.

We are not disposed to agree with those who assert that samples of milk containing less than the just stated proportions of cream and solid matter is to be necessarily

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[1] This is accomplished in part with the aid of the knife, the point of which is used to thoroughly break up the crusts. Careful trituration with an agate pestle will then complete the process.

regarded as having been adulterated with water. Such a thing as "standard milk" has no real existence in nature, since the quality and quantity are dependent, not only on the condition of the cow as regards health, but also on feeding, confinement or otherwise, length of time since calving, etc., and are also well known to be influenced by the breed of the animal. A standard by which we may distinguish "good" from "inferior" milk is useful, and may be fairly and legitimately established; but it is impossible to assert with truth that a sample of milk has been adulterated with water simply because the solids present happen to reach only 10 per cent., for we have met with cows which gave milk containing only 8 or 9 per cent. of solids on evaporation. Adulteration with water undoubtedly exists, but there is no known means of distinguishing water added from water secreted by the cow, unless the adulterating water happens to be laden with salts not found in cows' milk; hence there should be greater caution exercised than is usual at present in charging adulteration in a class of cases where the conclusion is really dependent so completely on a mere balance of probabilities. Our view of this matter is greatly strengthened by the fact that the last Adulteration Committee of the House of Commons have recommended that analysts should not in future use too rigid a standard in dealing with suspected samples of milk.

BUTTER.—*Adulterations.*—Water, much salt, starch, flour, dripping, and lard.

Good butter should not have a rancid smell. When a quantity is melted and poured into a small, narrow phial, and the latter allowed to stand near to a good fire, the milky layer of water that falls to the bottom of the bottle should not form more than one-tenth of the total bulk of fluid. When the melted butter is poured off, the water should not strike a blue colour when shaken with a drop of tincture of iodine. Under the microscope the fat when cold should not appear crystalline, but as if made up of oily globules. The

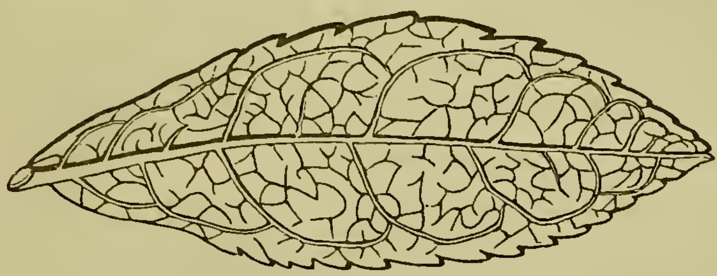
occurrence of crystals usually indicates admixture with animal fat.

TEA.—*Adulterations.*—There are two chief classes of teas—the green and black varieties. Under the first head are included—the Hysons, Twankay, and Gunpowder; and under black teas—Pekoe, Souchong, Congou, and Bohea. Both classes are subject to many serious adulterations at the hands of the exporters, and again on arrival in Europe. Mixtures of different kinds of tea are legitimately made in the course of trade for the purpose of suiting special tastes, but inferior varieties are often dishonestly mixed with the more costly kinds in order to increase profits. Leaving aside the consideration of "tea mixing," we find that green and black teas have often added the leaves of other plants. Those of the plum, sloe, ash, willow, poplar, hawthorn, beech, plane, orange, elm, horse-chestnut, elder, and oak, have been detected. These leaves are dried and prepared by roasting and "facing," so as to resemble genuine tea very closely. The product is sometimes called "Maloo mixture." Facing is used for the purpose of colouring the leaves and increasing weight. The bodies employed are China clay, gypsum, chalk, French chalk, black lead, Prussian blue, indigo chromate of lead, carbonate, and even arseniate of copper, Venetian red, and fine white sand. The powders are attached to the leaf surface by a convenient adhesive material.

Spent (exhausted) tea leaves, from which most of the five or six per cent. of *theine* usually present in good tea has been removed by water, are often dried, coloured with catechu and an iron salt, then faced, and the product mixed with good tea, "Maloo mixture," or Lie tea. The last-named substance is made up of the tea and other leaves, sand, or plaster of Paris, bound together by starch or gum, in order to form granular particles, which can be "faced," so as to resemble black or green gunpowder.

Genuine tea, when placed in a muslin bag and kneaded in

warm water for a few minutes, should not give up any powder, quickly subsiding when the water is allowed to stand. The moist fragments of leaves when spread out should be compared with the very characteristic figure of the genuine leaf given below. The thick looped veins of the true tea-leaves are easily recognised.



Good tea, when burnt in the platinum tray, should not afford more than five per cent. of ash.

Dry the tea-leaves thoroughly at the temperature of boiling water, and weigh off 100 centigrammes (one gramme) ; this is put into a flask, and 250 c. c. of water added, and the mixture then boiled for half an hour; the liquid is now poured on a filter which has been previously weighed after careful drying at the temperature of boiling water, and all the tea-leaves washed on to the paper, and then washed with a little distilled water; the filter, with its contents, is now taken out of the funnel and laid carefully on a glass plate and dried *thoroughly* at the temperature of boiling water and weighed; when the weight of the filter is subtracted, the residue gives the number of centigrammes of exhausted tea-leaves, and this weight should in the case of good tea reach 60 centigrammes.

Coffee.—*Adulterations.*—Chicory, acorns, sawdust, roasted roots of various kinds, and grain, tan, croats, lentil seeds, baked livers, Venetian red, burnt sugar. Admixture with chicory[1] is allowable if the compound be truly labelled.

[1] The microscope is alone able to detect mixtures of many organic bodies, as starches, fats, chicory, etc., in this and other cases. The simple tests given usually serve simply to exclude injurious substances.

Genuine coffee should not cake when pinched between the fingers. If a little be thrown on cold water it floats, and very slightly tinges the water. Adulterated coffee sinks and rapidly colours the water brown. Good coffee does not contain more than 1·3 per cent. of sugar, and affords less than 1 per cent. of ash, which latter ought to dissolve completely when digested for some time in strong hydrochloric acid. A residue indicates the presence of silica, which is not found in pure coffee, but is present in the ash of most of the bodies used to adulterate coffee.

Ten grammes of the coffee are weighed out and placed in a glass flask, and 100 c. c. of cold distilled water poured in. The mixture is then raised to the boiling temperature, and kept at this point for *one minute.* It is then rapidly filtered, the clear liquid allowed to cool down to 15·5° C., and the specific gravity taken by means of an *accurate* urinometer. Genuine coffee gives a decoction having a specific gravity not higher than 1·010; but if chicory (or most of the other adulterants) be present, the specific gravity exceeds 1·010, and sometimes reaches 1·020 when much chicory is present.

COCOA.—*Adulterations.*—Chicory, cocoa-husk, fats, starches, sugar, Venetian red, bole.

Genuine cocoa should not have a sweet taste, or a red colour. As much cocoa as can be piled up on a threepenny piece, when placed on a square of platinum foil, and strongly heated by a spirit lamp flame, should burn almost completely away, leaving less than 3 per cent. of a reddish coloured ash. The same remarks apply to CHOCOLATE.

VINEGAR. — *Adulterations.* — Sulphuric acid and other mineral acids, water, "grains of paradise," chillies, arsenic, and copper, as accidental impurities.

Unadulterated vinegar is allowed by special enactment to contain one-thousandth of oil of vitriol. When paper moistened with vinegar containing this proportion of sulphuric acid is dried before the fire, no charring takes place until the paper is rather strongly heated; but if the propor-

tion of acid is much greater, blackening results before the paper seems quite dry. It must be remembered that this is but a very rough and indecisive test. When a piece of clean and bright copper wire is immersed in vinegar, diluted with a little water, and heated nearly to boiling in a glass vessel, the copper quickly loses its colour and assumes a leaden hue if arsenic is present. Copper may be detected in a fresh sample, much diluted with water, by means of the steel needle, as described under *Preserved Fruits.* Pungent substances—"grains of paradise," for example—may be detected by evaporating a quantity of the vinegar nearly to dryness in any convenient porcelain vessel. The residue should not have a fiery taste. For arsenic test, see "Water Analysis, "page 226.

MUSTARD.—*Adulterants.*—Ordinary "mustard" is rarely free from admixture with one or other of the varieties of flour, turmeric being added to improve the colour. The addition of flour in moderate proportion may be permitted on the score of convenience, but turmeric should not be added. For flour, china clay, plaster of Paris, or chalk have been substituted, the colouring material being yellow ochre, or even the poisonous chromate of lead.

Mustard should not become brown when moistened with a little "spirit of hartshorn," and when burnt on platinum foil should leave not more than 6 per cent. of nearly white ash.

CAYENNE PEPPER.—*Adulterants.*—Dense flours or starches, mustard, turmeric, ochre, vermilion (?), red lead.

Cayenne when shaken with cold water, the mixture allowed to stand for a minute, and the liquid poured off, should not leave any heavy red powder at the bottom of the vessel. It ought to leave but 5 per cent. of ash when burnt on platinum foil.

CHEESE.—*Adulterants and Impurities.*—Setting aside such colouring matters as annatto, saffron, etc., we find that the

mineral pigments, Venetian red, (red lead?), are used, and various flours or starches to increase weight.

Cheese should not be eaten when in a mouldy condition, or when containing "jumpers." It ought not to become blue when touched with dilute tincture of iodine, and it should leave but little ash when burnt on platinum.

ISINGLASS.—*Adulterants.*—Though the best, or Russian isinglass, is an unimportant article of food, it is well to mention that it is sometimes adulterated with gelatine and with inferior Brazilian isinglass.

Genuine Russian isinglass occurs in opaque white filaments, which do not become transparent when placed in water, nor do they swell to a material extent. Gelatine, on the contrary, becomes transparent, and swells considerably Russian isinglass affords a firm, translucent jelly; the Brazilian variety, for corresponding weights of material and water, does not afford nearly so firm a jelly, and it is much more milky.

ARROWROOT (WEST INDIAN OR MARANTA).—*Adulterants.*—Potato starch, sago meal, rice, gypsum, china clay, chalk.

Genuine Maranta arrowroot is a dull white powder, which crackles strongly and in a peculiar manner when pressed between the fingers. When mixed with twice its weight of strong hydrochloric acid it yields an opaque jelly. Potato starch, under similar circumstances, affords a transparent jelly. When burnt on platinum foil, arrowroot will leave not more than 1 per cent. of ash if unadulterated with mineral powders. A fragment of iodine, placed on a warm plate near to the sample, colours Maranta arrowroot a chocolate brown, sago starch yellowish, wheaten starch violet, and potato starch a dull lilac tint.

CHAPTER XVIII.

WATER SUPPLY.

Division of the Subject—Allowance per Head—Probable Permanence of Supply—Quality of the Water—Influence of Soil and Rock Strata—Surface and Spring Water—Spas—Contamination of Wells by Animal Excreta—Church's Mode of Detecting Source of Impurity—Purification—Filtration; Boiling; Clarke's Process — Storage of Water in Reservoirs or Cisterns.

THE questions relating to water supply which the Medical Officer of Health may be fairly called upon to consider are those affecting—(*a.*) the allowance to be provided for each inhabitant per diem; (*b.*) the probable permanence of the supply; (*c.*) the quality of the water; (*d.*) its purification prior to distribution; and (*e.*) its storage in house cisterns. Engineering questions may be left out of consideration, as they are best dealt with by specially skilled advisers. Hence, in dealing with water supply, we shall consider, in the above order, the matters of interest to the sanitarian, without treading upon the ground properly occupied by the engineer.

(*a.*) *Allowance per head per diem.*—The average daily supply required for each inhabitant is estimated by Mr. Rankine at 22 gallons. This is, on the whole, a fair proportion, though, when possible, it is well to aim at a supply of 35 gallons per head, in order to admit of the free use of water for public and private baths and for general cleansing. Other conditions being equal, the largest proportion is undoubtedly the best for the sanitary condition of a town. If, however, an abundant but polluted supply, incapable of proper purification, and one more scant in quantity but excellent in quality, are compared, we should give the preference to the latter, as a comparatively small supply of good water, amounting to five or six gallons per head, may be made to suffice by strict economy in use.

(*b.*) *The probable Permanence of Supply.*—In the consideration of this point, the source of the water is an element of considerable importance. A few general remarks on the sources of drinkable water may, therefore, most suitably be made in this place.

The prime source of all water supply is, undoubtedly, the ocean, since in nature there is a continuous circulation from the sea to the air, then from air to rivers, and, finally, to sea again. The air in contact with the ocean becomes quickly saturated with the vapour of water, and then being carried by currents over the earth and suddenly cooled, deposits much of the aqueous vapour in the form of rain. If the soil be not porous, very small streams are formed, and these flowing into a common channel produce a river. If the soil be porous, the water percolates through it, and may drain away again at a lower level, and form rivulets and rivers, or it sinks into the subjacent permeable strata, thus serving to maintain the supply of wells and of natural springs, often situated at a great distance from the place of rainfall. If the permeable strata are not overlaid by those only slightly pervious, land-springs not rising above the surface are obtained over the district; but if the strata dip between two impermeable beds, an Artesian spring is obtained on boring at a lower level through the upper bed to the water-bearing strata. Land springs cannot be much relied upon for a permanent supply. Artesian springs, on the other hand, can be depended upon to a much greater extent if the outcrop of the pervious strata be considerable and the rainfall of the district high in which the strata reach the surface. The best water-bearing strata are the chalk, limestone, green sand, and the older metamorphic rocks; water can almost always be obtained with facility on boring sufficiently far into them, and, as might be anticipated, springs occurring in them or similar rocks, and situated at the base of a hill, usually yield an abundant and steady stream of water.

The usual source of supply to towns is the rain falling

on a given district, which is made to drain into a reservoir, or series of reservoirs, whence the water is conveyed and distributed. Local circumstances, *e.g.*, position, proximity to hills and to forests, etc., materially affect the rainfall of a district, and, therefore, the annual supply to be expected. A knowledge of the annual rainfall of a district is of the utmost importance in aiding the determination of the supply to be expected from a given catchment area. The mode of determining the rainfall will be described in the chapter on Meteorological Observations; and when once ascertained by a sufficiently extended series of observations, the calculations for the catchment area can be easily made, if it be remembered that a fall of 10 inches of rain yields 226,170 gallons per acre. If the receiving surface be the roof of a house, we find the yield of water by multiplying the area of the roof (expressed in square feet) by 144; and again multiplying the product by the rainfall (expressed in inches). The resulting number of *cubic inches* of rain may be expressed as gallons when multiplied by ·003,607, or divided by 277·274.

(*c.*) *The Quality of the Water.*—Absolutely pure water is not obtainable in nature, since rain derives impurity from the air through which it passes and from the soil on which the water falls. In the chapter on Water Examination and Analysis we will enumerate the impurities usually found in natural supplies, and describe the most convenient methods for their detection. Here, however, we would refer, very briefly, to the sources of the chief classes of impurities.

Rain water is commonly regarded as being particularly pure, and when collected in country districts, and on clean surfaces, it is so, undoubtedly. When caught on city house-tops, however, it is liable to contamination, not only by unpleasant sooty matter, but by animal exhalations, and even excreta, and ought not to be employed for dietetic purposes without boiling and filtration.

The quality of the supply from a large catchment surface of soil depends materially on the condition of the land as

regards tillage; for it is evident that water collected from a well-manured district cannot be so pure as that collected on a rocky and mountainous tract, from which the water readily flows to form large and rapid streams. In such a district we may have patches of peaty soil, abounding in vegetable *débris*, which may communicate a high colour to the water; but the risk of contamination by animal excreta is extremely small if the district be sparsely inhabited; and it is to be remembered that it is against impurity of the latter kind that the Medical Officer must be especially on his guard. Hence, water collected from a rocky and mountainous district is always to be preferred to that from cultivated and low-lying land. Again, comparing rocky areas amongst themselves, that one is to be preferred whose surface yields up least soluble matter to water; thus, a tract whose soil rests upon, and has resulted from the degradation of the older metamorphic rocks, granite, quartz rock, sandstone, etc., is usually a much better source of water supply than a chalk, limestone, or dolomitic district, as, in the latter cases, the water is certain to be more or less highly charged with dissolved lime or magnesian salts, which render the water "hard"—in other words, confer upon it the power of destroying a certain amount of soap, before any detergent effect can be obtained. (See chapter on Water Analysis.)

We have hitherto considered only surface water; but if the soil on which the rain falls be porous in any considerable degree, and the underlying rock strata sufficiently open, the water will percolate through the strata and saturate the lower-lying portions when its downward course is perhaps obstructed by less pervious layers. In its passage through the rock strata, often under considerable pressure, it dissolves out more or less of the soluble constituents of the strata, and makes its appearance in land-springs and natural or artificial Artesian wells or springs as a mineralised water. If the rocks through whose substance or fissures it passes in its downward course to find its level, happen to be the older

metamorphic, granitic, or quartzose rocks, or green-sand beds, but little impurity is taken up, and the springs usually yield a supply of very pure water. If the rocks are cretaceous, or magnesian, or both, the water is highly charged with lime and other salts, to an extent dependent on the particular salts present in the beds, and on their solubility. Water filtering through a bed of chalk dissolves but little of the latter, if the liquid be not charged with earbonic acid, since the amount of chalk (caleium carbonate) taken up bears a direct relation to the quantity of this dissolved carbonic acid. Sometimes, as in the case of the Carara springs, the water becomes eharged, perhaps under pressure, to an unusual extent with acid and with chalk, and on issuing from the souree loses much of its earbonic acid; the result of this loss is the deposition of the ehalk previously held in solution by the acid in stalactitic forms on any objects with which the liquid eomes in contact.

If instead of passing through strata eontaining lime, magnesian, or alkaline salts, the water eharged with carbonic acid comes in contact with decomposable ferruginous rocks, the latter yield up a portion of their iron as ferrous earbonate, which dissolves in the excess of carbonic acid, and forms the water of the chalybeate spa. These spas we often meet with in volcanie districts, and also in the neighbourhood of the coal measures. In the latter localities we rarely fail to meet not only with springs, more or less worthy of the name ehalybeate, but we also find the sulphur spas, the sulphuretted hydrogen of which has been derived from the decomposition of sulphides, always present in the shales and true coal beds, by infiltrating water charged with carbonic acid.

A general knowledge of the geology of a district, or of the rocks and rock beds oceurring in it will, therefore, materially aid the medical officer in arriving at a fair conclusion as to the impurities likely to be met with in the water derived from certain strata; it will also aid him, in the way we have indicated, in his search for saline, chalybeate, or sulphur spas in his neighbourhood. We may add that geologically coloured

Ordnance Survey maps of most districts in Ireland can now be obtained at a cheap rate through any bookseller.

We have hitherto considered, almost solely, the sources of natural and unavoidable impurities; we have now to draw attention to the sources of impurities which are, to some extent, avoidable or under our control. Of these sewage and factory contamination are the chief. The importance of these sources of impurity is in direct proportion to the number of towns situated upon a river, and is inversely proportional to the size and rate of flow of the stream. Where several towns are situated on the same river it is greatly to be desired that the sewage of each should be collected in large tanks outside the towns, quickly treated with crude sulphate of aluminium, or any of the other suitable deodorisers and precipitants for suspended matter. The precipitate when roughly dried would afford useful manure in the neighbourhood, while the clear liquid ought to flow partly over and in part through a considerable stretch of land before finally escaping into the river. Factories should be compelled to purify their waste waters before discharging them into the river. This purification is in almost all cases possible.

Wells in the neighbourhood of dwelling-houses are always liable to contamination, owing to the access of surface drainage or soakage from sewers or cess-pools. They should be placed as far from all source of contamination as possible, and well covered. If an examination of the water proves that it has been contaminated by sewage, and we desire to ascertain the source of the impurity, we may follow the ingenious plan of Church. This consists in throwing a little chloride of lithium into one of the suspected sources, and, after a day or two, examining the water, with the aid of the spectroscope, for lithium. This instrument will detect extremely minute traces of the metal, if any happens to have reached the well. It is, of course, necessary to ascertain at first that the water does not naturally contain traces of

lithium. If none of the rare metal makes its appearance in the water after sufficient time has elapsed, another possible source of contamination is settled upon, lithium chloride added to it, and the water tested as before. This process is carried on until the direction of the infiltration is precisely ascertained. If the infiltration can be prevented by the construction of a new pipe-sewer, the use of the water should be discontinued for some months, though the well should be regularly pumped out during the time, and then, after careful analysis, its use may, perhaps, be resumed. But if the soil in the neighbourhood of the well has become saturated with sewage matter, and if the source of contamination was a cess-pool, the well should be filled up, so as to effectually prevent the use of water from it.

(*d.*) *Purification of Water prior to Distribution.*—Purification of water, on the large scale, is either mechanical or mechanical and chemical.

Mechanical purification consists in filtration of the water through beds of gravel, sand, or other similar materials. The removal of suspended matter is effected in this way, and in some slight degree dissolved saline contents are separated. All water should be filtered prior to distribution to a town.

Amongst the chemical modes of purification which have been proposed, the process known as Dr. Clark's softening method is now regarded as the most effective that can be economically carried out. The process is, however, applicable only to water whose chief hardness is due to chalk dissolved by carbonic acid, and which is said to be only temporarily hard, because, on boiling a sample of such water, carbon dioxide gas is driven off, and the chalk deposits. If, instead of boiling, we add lime water, the calcium hydrate combines with the free carbonic acid, forming chalk which precipitates, together with the chalk previously dissolved by the acid. Hence, paradoxical though it seems, temporarily hard water is softened by addition of lime-water, and it must be admitted that the advantage does not end here, for the chalk, in

precipitating, carries down with it a very sensible proportion of any organic impurities which may happen to be in solution.

In order to purify by this process 100,000 gallons of water, we must know the number of degrees of *temporary hardness*.[1] If this happens to be 10°, we take 60 lbs. (6 lbs. for each degree) of freshly-burned lime, and slake completely with sufficient water. The slaked lime resulting is thrown into the tank, and stirred up with sufficient water (about 500 gallons), so as to form an even milk of lime. The remainder of the 100,000 gallons of water is then allowed to flow in, sufficient agitation being usually secured by the flow. After a time the milky liquid clears, owing to the subsidence of the chalk, and then, after filtration through a sand bed, can be distributed in a bright, clear, and relatively soft condition. The chalky residue may be used as manure.

Of all combined chemical and mechanical processes, this is now regarded as the most effective. We need scarcely say that the treatment can be as easily applied to small quantities of water as to large—the proportion above stated being preserved. The only objection to the process generally is, that the water resulting is rather insipid, owing to the removal of the previously dissolved gas. If desired, this effect can be avoided by artificially aerating the water after purification, as in Dr. Normandy's process for converting sea-water into that fit for drinking on ship-board, which we briefly refer to in another place, or by pouring the water repeatedly from one vessel into another.[2]

On the small scale, water may be easily purified to some extent by filtration either through sand filters or the animal charcoal filters sold for the purpose in great variety. Sand filters act chiefly in arresting suspended matter, but charcoal filters—especially those of animal charcoal—possess, *when freshly calcined*, the remarkable power of, in part oxidising, by

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[1] See chapter on "Water Analysis."
[2] See chapter on "Water Analysis."

means of oxygen condensed within its pores, and, in part, distinctly separating from solution the organic contents of impure water. But the charcoal quickly loses the purifying power, and requires re-calcination before it again becomes effective. Few filters that we have examined retain their *special* power for more than a few days, though their vendors assert that they continue to act for months; this they certainly may do, but only in the same mechanical manner as the sand filters. Though we appreciate highly the value of a *fresh* filter of animal charcoal, we cannot too strongly urge that no special reliance be placed on a filter which has been in use for some time. If a doubtful water must be used for dietetic purposes to some extent, it should be first thoroughly boiled, and then filtered through any convenient porous material. This is, on the whole, the safest plan to adopt in dealing with small quantities.

(*e*.) *Storage of Water in House Cisterns.*—This is a point which should receive much more than the usual amount of attention, as we have frequently known good water to have been rendered wholly unfit for drinking, owing to carelessness in its storage.

A cistern should be so covered as to be inaccessible to noxious effluvia, and ought to be secured against infiltration of drainage. It is by no means unusual to find the overflow pipe lead into the house sewer, or a close drain communicating with it, the probable effect of which is that the atmosphere of the cistern becomes charged with noxious sewer gas. The overflow pipe should be free to the atmosphere. In cities like Dublin it is not unusual to place the cistern under the hall-door step, and when insufficiently protected, the street drainage, urine, etc., easily finds its way into the water, and has been repeatedly detected by us in Vartry-water cisterns so situated. Moreover, cisterns require occasional examination and cleansing, since, even when carefully covered, the interior becomes more or less coated with matter deposited by the water, and if this be not removed,

t may become offensive, if of organic origin, and give rise to abundant confervoid growths. These remarks apply equally to cisterns of stone, lead, or wood. Stone-ware cisterns are, on the whole, probably least open to objection, but leaden cisterns and supply pipes require to be adapted in composition to the water they are intended to store or transmit. Ordinary hard water, containing much sulphates and carbonates in solution, can be safely allowed to pass through cisterns and tubes made of the ordinary commercial lead, for the surface of metal in contact with the water quickly becomes coated with a layer of sulphate and carbonate of lead, with, perhaps, other salts, which protect the metal from further action. If, however, the water be soft—*i. e.*, its hardness reaches five or six degrees, and is chiefly due to carbonates—the water easily becomes contaminated with lead, and its prolonged use may lead to the development of symptoms of lead-poisoning. The remedy for this state of things is the use of an alloy of lead and tin, containing 3 per cent. of the latter metal. The presence of the electro-negative metal prevents solution of the lead, and, therefore, contamination of the water. The knowledge of the important fact of the protective action of tin in lead tubing and sheet lead was first applied successfully in the case of the soft Loch Katrine water supplied to Glasgow. "Composition lead," as the mixture is called, is now used in Dublin also, since the Vartry water is nearly as soft as that of Loch Katrine.

CHAPTER XIX.

Examination of Water.

Impurities usually found in Water.—Mineral.—Organic.—Sewage Contamination.—Standards of Quality.—Methods of Examination, Turbidity, Colour, Odour, Taste.—Gases dissolved in Water.—Detection of Sulphuretted Hydrogen.—Acidity or Alkalinity.—Detection of Nitrites; of heavy Metals.—Estimation of Total, "Temporary," and "Permanent" Hardness.—Total Solid Contents.—Estimation of Ammonia; of Ammonia derived from Azotised Organic Matter, by Nessler's Test.—Estimation of Chlorine; of Nitrogen, as Nitrites and Nitrates.

In the last chapter we have treated generally of the subject of water supply; it now remains for us to state the physical and chemical characters or qualities which "good water" should possess, and then to explain the most convenient means the medical officer can employ in testing a given sample. As we have already shown, perfectly pure water is not obtainable out of the chemical laboratory. The impurities always present in solution are derived in part from the atmosphere through which the rain falls; but chiefly from the soil through which it percolates. The foreign matters are usually of mineral and of organic origin. Under the head of mineral or inorganic impurities we include the free acids—sulphuric, hydrochloric or muriatic, and silicic acids; the sulphates, carbonates, chlorides, nitrates and phosphates of calcium, of magnesium, of the alkaline metals; and compounds of copper, iron, lead, arsenic, etc., together with the gaseous bodies, sulphuretted hydrogen, ammonia, carbon dioxide—or carbonic acid, nitrogen and oxygen. The organic impurities are very varied, and may consist of nitrogenised and un-nitrogenised compounds of carbon with hydrogen, and sometimes other of the chemical elements. The mineral impurities are usually present in the largest proportion, but

their relative importance in determining the quality of the water is exceedingly small. It is true, however, that the use of water for dietetic purposes containing lime salts (especially the sulphate) in considerable quantity, is liable to produce gastric derangement, and, when the proportion is very high, goitre, and the peculiar form of idiocy termed cretinism.

No injurious effects have been hitherto traced to the use of water containing even a considerable proportion of organic bodies of the unnitrogenised kind; but if sensible quantities of nitrogenised organic substances are dissolved, a sample is to be regarded with suspicion, chiefly because the presence of bodies of this class in solution is held to be presumptive evidence of sewage contamination, and it has been repeatedly shown that the prevalence of certain epidemics could be connected with the use of water known to be mixed with sewage. Fortunately, evidence of sewage contamination does not rest solely on the detection of nitrogenised organic matter, else pure water containing a very minute trace of *quinine* would be declared unwholesome; but the occurrence of *chlorine* in considerable proportion is regarded as tending greatly to strengthen the suspicion that animal refuse has been allowed to mix with the water, since all sewage contains common salt (chloride of sodium) in comparatively considerable quantities.

Fresh sewage, whether concentrated or dilute, speedily undergoes putrefactive change, and when in this state of decomposition is known especially to favour the development of low forms of organic life; it is also reasonably supposed to promote the growth and multiplication of those "disease germs" which are believed to be present in the excreta of cholera or other patients, and to whose free distribution, by means of contaminated water and otherwise, the spread of epidemics is usually attributed. In the early stage of putrefaction a portion of the nitrogen of the organic matter is converted into ammonia, but—as the process continues—oxygen, derived principally from the atmosphere, oxidises the nitrogen

to nitrous and ultimately to nitric acid. Hence water whose nitrogenised constituents have undergone complete decomposition and oxidation will contain only nitrates.[1] If the change has been less complete, *nitrites*, a little ammonia, and some residual nitrogen in organic combinations, will appear, ammonia and "organic nitrogen," with minute, if any, traces; while at the earliest stage of the putrefactive process much of nitrates and nitrites will be found.

In the examination of water for sanitary purposes it is, therefore, of importance to ascertain not merely the presence of combined nitrogen, but also its condition and amount. Much of this information can be obtained with a comparatively small expenditure of time and trouble by following the plan we shall presently lay down.

Experience has shown that few waters are quite free from organic matters, and none from mineral impurities; we must, therefore, rest content with demanding that a given sample shall be wholly free from certain bodies, and contain others in minute, and, as we are led by experience to suppose, safe proportions. What our requirements are we will now state, only premising that, according to the writer's somewhat large experience of Irish waters, the standards fixed are low rather than too high.

GOOD WATER should be quite clear, and free from all but a trace of colour, and from unpleasant odour and taste.

It must not contain sulphuretted hydrogen or a sulphide.

Its reaction to test papers should be neutral or faintly alkaline after boiling.

It ought not to contain *nitrites*.

It should be free from lead, copper, and arsenic, and from more than minute traces of iron and manganese.

The total "hardness," or soap destroying power, should

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[1] The proportion of nitrogen in this condition measures, according to Professor Frankland, the "previous sewage contamination"—one part of nitrogen representing about 9,000 parts of average filtered sewage.

not exceed 18 or 20 degrees, and the "permanent hardness," or hardness after boiling, ought not to exceed 6 degrees.

The water should contain *less* than the following proportion of the five bodies enumerated :—

Substances found	Centigrammes in 1 litre;[1] 1 litre=100.000 centigrammes	Parts in 100,000	Grains in 1 imperial gallon; 1 gall.=70,000 grains
Total solid contents, dried at 100° C., or 212° F. -	40·00	40·00	28·000
Ammonia - - - -	·01	·01	·007
Ammonia derived from azotised organic matter -	·02	·02	·014
Chlorine - - - -	1·00	1·00	·700
Nitrogen in nitrates (and nitrites) - - -	1·00	1·00	·700

In conducting the examination of a sample of water, the medical officer may only require to ascertain whether the sample fulfils the conditions stated above, or he may desire to find *how much* of each constituent is present. An examination of the first kind is easily conducted and quickly completed, if the plan we shall now describe be carefully carried out; but the fuller quantitative analysis requires more time and skill. The instructions for carrying out the latter process are printed in smaller type in order to avoid confusion; and, for a similar reason, all apparatus and solutions of chemicals required in conducting either system of analysis will be found described in Appendix II.

CONDUCT OF THE EXAMINATION AND ANALYSIS.

Turbidity is easily observed by placing a flask containing

[1] For a short explanation of the metric system of measures and weights, see Appendix II. One centigramme is equal to slightly more than $\frac{1}{6}$ grain.

about a litre of the water on a black surface and strongly illuminating. If much mechanically-suspended matter be present, it should be allowed to subside, and then examined for animal and vegetable organisms with the aid of the microscope.[1] Water in which these are present in considerable amount should not be used; and however slightly turbid a sample may be, and however good in other respects, it ought to be filtered carefully before use, either for drinking purposes[2] or for analysis. Filtration through fine white bibulous paper should, therefore, precede the application of any of the following tests; and it is well in commencing an examination of water to filter off about four litres, taking care to throw away the first half-litre passing through the paper.

Colour.—Fill a litre flask, made of colourless glass, with the filtered water and place it on a sheet of white paper; any traces of colour will then appear. When a sample of the Vartry water now supplied in Dublin is treated in this way, it is seen to possess a brown tint, owing to the presence of "humic" compounds in solution derived from a peaty soil, though the water is very good in other respects.

Odour.—Shake in a clean bottle and smell. A faint odour thus detected may be strengthened by warming the sample.

Taste.—Good water should be brisk and agreeable to the palate, though we have frequently met with samples that tasted remarkably well, but turned out, on further examination, to be largely contaminated. The effect on the palate is due almost wholly to the degree of aeration of the sample. The purest and most carefully-prepared distilled water, because almost free from dissolved gas, is flat and insipid; but if charged with atmospheric air or carbonic acid gas, it becomes sparkling and agreeable. Much importance is

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[1] For excellent figures of the organisms usually found, see *Parkes' Manual of Practical Hygiene.* Fourth Edition. P. 60.

[2] See section on "Water Purification." Page 216.

attached to the degree of aeration of water employed for dietetic purposes, as water highly charged with air is said to be more easy of digestion than that which contains but little. This has been recognised in Dr. Normandy's patent process for providing pure water in ships. Salt water is distilled, and the condensed liquid thus freed from mineral impurities is charged with atmospheric air in a special apparatus, and is thereby converted into a brisk and agreeable drink.

The air dissolved in pure water contains a much larger proportion of oxygen than ordinary atmospheric air, the percentage composition and volume of the gases extracted from pure rain-water being—

	Gases dissolved in rain-water	Gases in atmospheric air
Oxygen - -	34·00	20·80
Nitrogen - -	63·72	79·16
Carbon dioxide -	2·28	·04
	100·00	100·00

Rain-water contains about $\frac{1}{40}$th of its volume of dissolved gases.

The oxygen in solution is to be regarded as a most effective cleansing agent, capable of rapidly destroying accidental organic impurities and preserving the water in a wholesome condition; its absence, therefore, is a decided disadvantage. The accurate determination of the gases dissolved in water, however, is a matter of such difficulty, and requires the use of so much rather expensive apparatus, that the process can be properly conducted only in a well-furnished chemical laboratory.[1] Moreover, it is not of great practical value, as a sample containing but little dissolved oxygen will usually exhibit other defects, leading to its condemnation.

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[1] The reader will find the best instructions in this branch of analysis in *Bunsen's Gasometry*, translated by Roscoe from the German. The necessary apparatus can be seen in the laboratory of the Royal Dublin Society.

Sulphuretted Hydrogen and Sulphides.—If sulphuretted hydrogen be present, its characteristic and offensive smell of rotten eggs will be easily distinguished, but satisfactory proof of its presence is readily obtained by suspending from the cork of a bottle containing some of the water a strip of lead-paper[1] so as to approach, but not touch, the surface of the liquid; discoloration of the paper quickly follows, owing to formation of dark sulphide of lead, if the sample contains any free sulphuretted hydrogen.

To test for alkaline sulphides, place a considerable quantity of the water in a white dish, and add a drop or two of solution of nitro-prusside of sodium; a violet tint is instantly developed if a soluble sulphide be present. Water containing sulphuretted hydrogen or a sulphide is quite unsuited for domestic use.

Reaction.—Boil some of the water in a glass flask for a few minutes, and then test with blue and with red litmus paper. Blue litmus should remain unchanged, and the reddened litmus will usually become violet, indicating faint alkalinity of the water. If a strong blue tint be produced, the water probably contains an alkaline carbonate in solution.

Nitrites.—Put a quarter of a litre into a colourless glass bottle, and add a few drops of thin starch, made by boiling a little with water. Then add a few drops of pure dilute sulphuric acid; mix well, and pour in a small quantity of pure iodide of potassium solution; mix again, and allow to stand for five minutes. If no *blue colour* be developed in that time, nitrous acid and nitrites are absent. If a blue tint be produced, make a similar experiment with pure *distilled water* and starch, dilute sulphuric acid and iodide of potassium as before; no colour should be produced. The reason for this precaution is that the commercial iodide (owing to the presence of iodate) occasionally produces a blue colour with starch and dilute acid, though no nitrites are in the solution;

[1] See Appendix II.

it is, therefore, necessary to test the iodide in this way, and if it proves impure, to obtain a new sample.

Metals.—The examination for metals may usually be left to the end of the analysis, but we shall describe the requisite treatment in this place. Acidulate half a litre of the sample with a few drops of pure hydrochloric acid, and add a little sulphuretted hydrogen water; place the flask containing the mixture on a sheet of white paper. If the slightest brownish discoloration be produced after some time, lead or copper (mercury, bismuth, or silver) is present, and the water must at once be discarded as being unsafe. If it be desired to know which metal is present—mercury, bismuth, and silver being left out of consideration, owing to their extremely improbable occurrence in water—it will be necessary to evaporate several litres to a very small bulk, and to add ammonia until the liquid smells strongly of it; then filter. The clear liquid running through the paper will have a faint blue colour if copper be present; and when evaporated to dryness, and the dry residue touched with solution of ferrocyanide of potassium, will give a brown coloration. If copper be absent, lead must be the metal that caused the darkening with sulphuretted hydrogen.

Arsenic, if present, is detected when a litre of the water is evaporated nearly to dryness, with the addition of a little pure caustic soda solution; the residue then treated with excess of strong and pure hydrochloric acid, and the liquid introduced into Marsh's apparatus, containing pure zinc. The hydrogen, evolved by the action of the acid upon the zinc, is lighted, *after all air has been expelled from the flask*, and a piece of white porcelain is depressed on the flame. If a black spot be produced, which easily dissolves in solution of chloride of lime, arsenic was present in solution in the water. The purity of the reagents must be ascertained by a blank experiment before the water residue is tested for arsenic. Water containing this metal must, of course, be condemned.

To test for iron, acidulate a litre of the water with pure

dilute sulphuric acid, and add a few drops of ferrocyanide of potassium solution. If much iron be present, a strong blue colour will be developed; but if only a "*minute trace*," the blue tint will be scarcely perceptible.

To test for manganese, place a litre of the water in a white basin, add a few drops of a clear solution of bleaching powder and acidulate with pure dilute acetic acid; if a faint brown colour be developed, after some time, the presence of manganese is indicated. We have frequently detected manganese in well-waters from the south-west side of Dublin, from Sutton, near Howth, and from the southern portions of county Cork.

Hardness.—This term is used to indicate the soap-destroying power of a water, which is chiefly due to the presence of dissolved calcium and magnesium salts. Ordinary soft soap, prepared from olive oil, consists, for the most part, of potassium oleate. We may, in order to fix our ideas, imagine a solution of this soft soap mixed with water containing a little calcium chloride. Double decomposition then takes place, the products being potassium chloride and calcium oleate; but the latter is a nearly insoluble body, and is, therefore, precipitated in curdy flakes. If we continue the addition of the solution of soap to the liquid, a point will be reached at which the whole of the calcium will be precipitated and an excess of the alkaline oleate will appear in the mixture. Now, on agitation of the liquid, a persistent froth or "lather" is obtained; but, before the complete precipitation of the calcium, no such "lather" could be produced; hence "lathering" is a sign that the double decomposition is at an end. If, then, we have a soap solution whose power of precipitating pure calcium chloride is known, it is clear that we are in a position to measure the calcium chloride, or equivalent quantity of any other calcium salt, in a natural water, by adding cautiously to the latter a measured volume of the soap solution, until a permanent froth is produced on shaking the mixture. Magnesium salts act in a precisely

similar way in destroying the lathering property of soap; hence, in applying the test to a water containing both calcium and magnesium salts, the full effect is the sum of the effects due to dissolved calcium and magnesium salts respectively. This test is, therefore, to be regarded only as a rough though useful means of measuring the soap-destroying power of a given sample of water, and the importance of this is evident when we recollect that no lathering or detergent effect is obtained from soap until the whole of the calcium and magnesium salts have been precipitated. This involves the loss of a corresponding amount of soap; hence there is considerable waste in using a water rich in mineral matter, and which requires a large proportion of the test for its precipitation.

We owe the plan of measuring hardness that we have briefly sketched above, to the late Dr. Clark, of Aberdeen, who took as his standard of hardness water containing 16 grains of pure calcium carbonate, dissolved in one gallon. This solution he called water of "16 degrees of hardness." The standard water, whose preparation we describe in Appendix II., corresponds exactly with this, but is made with the aid of metric weights and measures. It must be distinctly understood, however, that the volume of soap solution used is not strictly proportional to the amount of calcium (or magnesium) salt present in a sample of water. And as the test really measures only the "soap-destroying power," it seems to us useless to attribute any other meaning to the term "degree of hardness" than that a given volume of the water decomposes the soluble soap in a certain number of c. c. of the standard test, prepared as described in the Appendix. Each c. c. of the test then naturally represents one degree of hardness.

If now we desire to know whether the hardness of a given sample of water exceeds or falls short of 16 degrees (see Appendix II.), 50 cubic centimetres are measured into a well-stoppered bottle, and 16 cubic centimetres of the standard soap solution (see Appendix II.) added in small quantities at

a time, the liquid in the bottle being violently shaken after each addition. When 16 c. c. have been added, the mixture is again shaken, and then observed. If the surface of the liquid be covered with a persistent "lather," then the hardness of the sample was less than 16 degrees; but if a lather be not formed, the hardness is greater than 16 degrees. If, on the addition of 2 c. c. more of the soap solution, the lather does not yet appear, the hardness is greater than 18 degrees; but if 2 c. c. additional of soap solution produce no permanent lather, the hardness is greater than 20 degrees. The observer, however, cannot go beyond this point without adopting special precautions, which we shall describe below. The analyst will now be in a position to state that the *total hardness* exceeds, or falls below, 18 or 20 degrees.

Much of the hardness of ordinary water is due to the presence of calcium carbonate, or chalk, and magnesium carbonate, dissolved by carbonic acid. When this water is boiled for some time, the carbon dioxide is driven off, and the two carbonates, being nearly insoluble in pure water, are precipitated in the solid form, and the hardness is reduced by a proportional amount. If, however, sulphates and chlorides of calcium and magnesium are present in addition to the carbonates, they remain dissolved after boiling the water. The hardness removed by boiling is called "temporary," and that not so removable is called "permanent." Water whose total hardness is high is very objectionable for use in steam boilers, owing to the thick incrustations of lime and other salts produced by evaporation.

To determine the permanent hardness, we take a quarter of a litre of the water, and boil in a large flask until the bulk has been reduced one-half; when the liquid has cooled to the ordinary temperature, we add distilled water until the turbid mixture measures exactly a quarter of a litre. After filtration through paper not previously moistened, we take 50 c. c., as in the previous estimation of hardness, and then add 6 c. c. of the soap solution. If, after the shaking, no lather is

formed, we can state that "the permanent hardness of the sample exceeds 6 degrees."

The writer has frequently analysed water from wells in and around Dublin, whose permanent hardness exceeded 25 degrees. This was due to dissolved gypsum—hydrated calcium sulphate.

The precise determination of the hardness of a water consists in the cautious addition from a burette (see Appendix II.) of the soap solution, centimetre by centimetre, to the 50 c. c. of water, and in less quantities as the end of the process approaches; the mixture should be, of course, well agitated between each addition. The number of cubic centimetres used indicates, as before, the total hardness. The permanent hardness is determined in the same way in 50 c. c. after boiling, diluting, and filtering the water, as above described.

If the hardness exceeds 20 degrees, the indications of the soap test will be less regular; in order to overcome this difficulty, however, Dr. Clark essentially directs that 25 c. c. only shall be taken, and 25 c. c. of pure distilled water added, and the mixture treated with soap test, as usual; the number of c. c. employed, when doubled, gives the degree of hardness.

Example.—A sample of water, the total hardness of which proved to be over 20 degrees, was diluted with its own bulk of pure water, and 50 c. c. of the mixture taken, 14 c. c. of soap test were required. As but half the usual quantity of water was taken for experiment, we had to multiply the number of c. c. of soap test by 2; therefore, 28 degrees was the hardness of the water.

Total solid contents.—Take a quarter of a litre (250 c. c.) of the water. Evaporate this in a thin glass capsule, heated by the water bath.[1] The capsule need not hold more than 100 c. c., as the water can be added in successive portions as the evaporation proceeds. Of course care must be taken that no dust gets into the capsule. When the water has been evaporated to dryness, the capsule must be heated by the boiling water for half an hour longer. It is then rapidly removed, the outside quickly cleaned, and the whole allowed to cool under a glass shade. It is well to place this shade on a plate, and to have under it a wide-mouthed vessel containing

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[1] See Appendix II.

some oil of vitriol, in order to dry the air, and so to prevent the residue in the capsule from absorbing moisture while cooling. When cold, the capsule and contents are weighed, and, from the result, the previously ascertained weight of the capsule subtracted. The difference is the "total solid contents, dried at 212° F.," afforded by a quarter of a litre, and this value, when multiplied by 4, gives the contents per litre.

Example—

	Grammes.
Weight of capsule and residue from 250 c. c. of water, - - - - -	36·5477
Weight of capsule alone, - - - -	36·4715
Residue from 250 c. c. =	·0762
	4
	·3048 grm.,

or 30·48 centigrammes per litre.

The residue is always to be reserved in order that nitrates may be tested for, and, if necessary, estimated in it.

If the number of centigrammes per litre of any substance be known, multiplication by ·7 will give the number of grains per gallon, should this method of statement be preferred. Thus, in the above case, $30·48 \times ·7 = 21·336$ grains per gallon. In order to convert grains per gallon into centigrammes per litre (*i.e.*, parts per 100,000) we have simply to divide by ·7, thus:—$21·336 \div ·7 = 30·48$ centigrammes.

Ammonia.—Under this head is included all ammonia driven off from a sample of water by rapid distillation with sodium carbonate. Any nitrogen present in the water, in the form of urea or of allied bodies, is converted into ammonia by the treatment we shall now describe.

Take a clean stoppered retort, capable of holding nearly a litre, and connect it, by means of a piece of India-rubber tubing, with the tube of a Liebig's condenser. Fix the retort in position on a square of wire gauze. Place some distilled water in the retort, and apply either a large Bunsen

gas flame or a spirit-lamp flame below the gauze, and distil rapidly until a few hundred cubic centimetres have passed over, then disconnect the apparatus, and throw out the residual water in the retort and the distillate, since the object of this treatment is to secure the cleanliness of the apparatus. Again connect the retort with the condenser, and pour into the former half a litre, by measure, of the water, and add as much recently-ignited "bread-soda"[1] as could be piled on a shilling; then replace the stopper, and distil rapidly, with a good large flame. The liquid that distils over contains the evolved ammonia, and is received in one of the glass cylinders[2] capable of containing rather more than 200 c. c. Continue the distillation until 200 c. c. of liquid is obtained, and then replace the cylinder by another of the same capacity. Then cover the first cylinder carefully; label it "ammonia from $\frac{1}{2}$ litre of water," and set it aside. We shall call this "distillate A." Next add to the contents of the retort about 50 c. c. of the "alkaline permanganate solution,"[3] and continue the distillation rapidly,[4] as before, until 200 c. c. more have passed over. We shall call this "distillate B." The process is then at an end.[5]

To the first distillate two c. c. of the Nessler test are now added, and mixed thoroughly, by stirring with a clean glass rod. The cylinder is placed on a sheet of white paper, and the depth of the yellow tint observed after five minutes' standing, and compared with that produced by the same quantity of the test when added to another similar cylinder, containing 1 c. c. of the standard ammonia[6] solution, diluted

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[1] Bread-soda heated strongly, in a spoon, over a spirit or gas flame.

[2] See Appendix II.

[3] See Appendix II.

[4] The liquid sometimes bumps violently during distillation. This may usually be remedied by introducing a few pieces of platinum foil into the retort. The distillate from the permanganate should be perfectly colourless; if of even a very faint pink colour, the whole process must be repeated.

[5] See Appendix II.

[6] See Appendix II.

to 200 c. c. with water free from ammonia. If the brown tint produced by the Nessler, in the first distillate (A), from half a litre of the water under examination, be deeper than that caused by the test in the cylinder containing 1 c. c. of the standard ammonia solution (·005 c. gr. of NH_3), the sample contains more than ·01 centigramme of ammonia in a litre, and is, therefore, to be regarded with suspicion, especially if the tint be much deeper than the standard.

The distillate B from the water now serves to determine the final point—namely, whether the sample yields more than ·02 centigramme of ammonia per litre, derived from azotised organic matter, other than urea and allied bodies. The tint produced by the Nessler solution in the cylinder of distillate is compared with that caused by the test in 200 c. c. of pure water, containing 2 c. c. of the standard ammonia. If the water be good, the tint caused in distillate B should be less deep than in the standard.

When it is necessary to find how much above or below the standards we have given above the sample of water happens to be, we proceed in the following manner. If the tint produced in distillate A appears to be three times as strong as in the standard for it (*i.e.*, 200 c. c. of water containing 1 c. c. of ammonia solution), we take another cylinder and measure into it carefully 3 c. c. of standard ammonia solution, dilute to 200 c. c. with pure water, and add the Nessler test. If our guess happened to be correct, then the tint should correspond with that observed in the cylinder of distillate A, but if the tints do not agree completely, a fresh trial is made with a different quantity of the standard ammonia, until the precise tint of distillate A has been imitated. Let us suppose that 3 c. c. of ammonia solution exactly suffice, then the water contains three times the standard quantity of ammonia, or ·01 $\times$ 3 = ·03 centigramme of ammonia per litre. It must be remembered, however, that in making these comparisons fresh quantities of standard ammonia must be diluted to 200 c. c. each time. Error will result only if one or two c. c. of the ammonia are added to a liquid already containing Nessler, as a precipitate will almost certainly be formed, and render an accurate comparison of tint impossible.

In the case of distillate B we proceed in precisely the same way, but it must be recollected that the comparison quantity of ammonia in this is double that in the former case, or 2 c. c. in 200 of water.

We may add, before concluding this part of our subject, that the "Nessler test" for ammonia was discovered by a chemist of that name. So delicate is the reaction that one part of ammonia in 20,000,000 of water can be distinctly detected with its aid. The application of this extremely sensitive reagent to quantitative estimations of ammonia was made by the late Mr. Hadow, but its use in water analysis was brought prominently under the notice of chemists by the late Dr. W. A. Miller, Professor of Chemistry to King's College, London. The special method of separating, in the form of ammonia, the nitrogen of certain organic matters by treatment with "alkaline permanganate," was devised by Messrs. Wanklyn, Chapman, and Smith, to whose interesting researches in this point we are indebted for the simple plan we have described for detecting, and even approximately measuring, the nitrogen present in this "albuminoid" condition in a sample of water. The ammonia they obtain by the alkaline permanganate treatment they speak of as "albuminoid ammonia;" but we have throughout avoided the use of this term, as it appears to us to involve an unnecessary assumption, and to be liable to mislead.

A method of water analysis, much more elaborate than that which we have described, has been devised by Drs. Frankland and Armstrong, of London, but its performance demands such an amount of skill, of time, and of apparatus, as to place it almost beyond the reach of Medical Officers of Health. We have not described it therefore, but the reader will find a good description of the process from the pen of Mr. Thorpe, in Sutton's *Volumetric Analysis*, at p. 246, and the full apparatus can be seen in the laboratory of the Royal Dublin Society, Kildare-street.

Chlorine.—In order to determine whether or not a sample of water contains more than our standard quantity of chlorine, we add to a litre two drops of colourless, pure nitric acid (free from all traces of chlorine), and then 10 c. c. of the standard silver. The liquids are well mixed, and the

whole allowed to stand for an hour. A white precipitate of chloride of silver forms, which settles after a time. A little of the clear supernatant liquid is poured off into a test tube, and a drop of weak solution of common salt added to it. If no cloudiness be produced, the 10 c. c. of silver solution did not suffice to precipitate all the chlorine present in one litre ; and since 10 c. c. exactly precipitate 1 centigramme of chlorine, the litre of water must have contained more than this proportion of the latter, and, therefore, must be less pure in this respect than the standard. If, on the other hand, even a faint turbidity be produced by the common salt, silver is in excess, and the chlorine present must be less than 1 centigramme per litre.

We shall now explain the plan we have arranged for the estimation of the precise weight of chlorine in a litre of the water.

Every cubic centimetre of our silver solution is capable of converting ·1 of a centigramme of chlorine into the insoluble chloride of silver. A c. c., therefore, corresponds to and measures this weight of chlorine. Let us now suppose that a litre of water really contains ·8 centigramme of chlorine, and that we add to the liquid 10 c. c. of our standard silver solution, the silver in 8 c. c. only of the solution is precipitated as insoluble chloride, and the metal contained in 2 c. c. only remains in solution in 1010 c. c. of the liquid. It is clear that, if we can ascertain the number of c. c. of silver test remaining unaltered in solution after partial precipitation, we find by difference the number of c. c. precipitated by the chlorine in a litre of water, and, consequently, the amount of chlorine in the water. It is, therefore, only necessary to possess the means of accurately estimating small quantities of silver, and the iodide of starch test liquid, described by Pisani (see Appendix II.), is the solution we find best suited to the purpose. This liquid has a deep slate-blue colour, and is instantly decolorised by a silver solution, slightly yellow iodide of silver being precipitated, and the precipitation is known to be complete when the blue colour no longer disappears. Our mode of operating is as follows :—Take a litre of water, and after addition of the two drops of acid find, as before described, whether 10 c. c. of silver suffice for complete precipitation; if not, take a fresh litre and add the same quantity of acid, but now 20 c. c. of silver ; and if this addition still prove insufficient, take again a fresh litre, and add acid and 30 c. c., and so on, until an excess of silver is certainly present. We will suppose that 20 c. c. suffice. Now filter through previously moistened *Swedish*

filtering paper, and throw away the first 300 c. c. passing through the paper. The residue must be filtered into a clean dry glass beaker. If not quite bright and clear, the liquid must be refiltered through the same paper. Measure off 250+5[1]=255 c. c. of the clear filtrate into a porcelain basin, and add a good pinch of precipitated chalk free from chlorine (the amount is not important), and stir well. Then run in from a burette the iodide of starch solution, stirring all the time. The point at which the blue colour no longer disappears is noted, and the number of c. c. of the starch solution read off. If now we know how many c. c. of the iodide of starch correspond to each c. c. of silver solution, we can state, with great accuracy, the number of c. c. of silver remaining in solution in 255 c. c. of our filtrate (*i.e.*, 250 of water), and this multiplied by 4 gives the number per litre of water. We have, then, simply to subtract the c. c. of silver in excess from the added quantity in order to find the number used up in precipitating the chlorine in one litre of the water.

Example.—Took one litre of well-water, added 2 drops of nitric acid, and treated with 20 c. c. of silver solution. Found excess of silver in a portion tested with common salt. This portion was not added to the bulk, but was thrown away. Filtered and rejected first 300 c. c. Took 255 c. c. subsequently of clear filtrate, treated with chalk, and added iodide of starch—6 c. c. of the starch liquid decolorised. Therefore, 24 (6×4) c. c. would be required for silver in solution in the whole 1020 c. c. Now 8 c. c. of our iodide of starch exactly represent 1 c. c. of the silver[1] solution; therefore, $24 \div 8 = 3$ c. c. of silver in excess. Hence, in our experiment, 17 c. c. of the silver solution were used up in precipitating the chlorine in a litre of water; therefore, $17 \times \cdot 1 = 1 \cdot 7$ centigrammes of chlorine are present in 1 litre of the water.[2]

If a sample of water happens to contain sulphuretted hydrogen, alkaline sulphides, or iron in solution, it is necessary to treat it as follows before proceeding as above:—Boil a litre for half an hour with a few drops of strong nitric acid, allow to cool completely, and make up to a litre again by addition of distilled water. Then treat with silver, as usual.

Nitrates and Nitrites.—Take 1 c. c. of a solution of nitre containing 1·8 centigrammes of the salt[3] and evaporate to

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[1] 5 c. c. is the fourth part of the 20 c. c. of silver added.

[2] This was easily ascertained by adding 5 c. c. of silver solution to 250 c. c. of pure water, mixed with a little chalk. 40 c. c. exactly of the iodide of starch were decolorised, and 8 c. c. of the iodide are decolorised by 1 of the silver solution.

[3] Prepared by dissolving 180 centigrammes of potassium nitrate in 100 c. c. of water.

dryness in a glass capsule. Place the capsule on a sheet of white paper, allow to cool, then add 2 c. c. of pure concentrated sulphuric acid, and stir well after throwing in a small clear crystal of green vitriol (ferrous sulphate); a dark brown tint will be produced.

Take the glass capsule containing the residue of the evaporation of 250 c. c. of water (see *ante*, page 230), and treat it in exactly the same way with sulphuric acid and green vitriol. If the water contains 1 centigramme of nitrogen per gallon as nitrate or nitrite, the tint developed will be of the same intensity as that caused by the nitre used above as a standard for reference.

This is a very rough but useful plan. When results of precision are required, the process we prefer is that of Thorpe, which will be found fully described at page 315 of *Thorpe's Quantitative Analysis*; but since the estimation is not one of much practical importance to the Sanitary Officer, we content ourselves with giving the reference to a good description of the process.

CHAPTER XX.

House Construction.

Site.—Of Town and of Country Houses—Aspect—Subsoil—Shelter. Walls.—Solid and Hollow—Warmth and Dryness, how secured in construction of Walls. Accommodation. Sanitary Arrangements.—Water-closets—House Drains—Precautions to be observed in Laying—Sewer-gas—Modes of its Entrance into Houses—Removal of Sewer-gas—Ventilation of Sewers.

Site.—In towns sites can seldom be chosen by the person who purposes building, as the site is to a great extent, if not altogether, determined by the laying out of the streets of the town. In laying out new streets or new towns, care should be taken to accommodate them to the sites of future houses. Sufficient space should be secured both in front and rere for any houses which may be built. This space should be sufficient, not only for free traffic, but also for free circulation of air; and care should be taken that sufficient space is preserved between opposite houses to prevent the houses on one side from intercepting the direct sunlight from the other.

For country houses or cottages sites should be elevated, so that a fall from the building may be secured in one direction at least. The house should be exposed to the south or south-east when possible. The following Table, taken from Mr. Eassie's papers in the *Sanitary Record*,[1] will show why these aspects are selected:—

Aspects	Subject to	Remarks
E.	Dryness and bitter winds.	
S.E.	Dry weather; mild winds.	Best aspect.
S.	Sultriness.	
S.W.	Much rain; boisterous winds.	Worst aspect.
W.	Rain.	
N.	Cold.	

[1] *Sanitary Record*, July 25, 1874. P. 59.

It is doubtful whether a south-west is really the "worst aspect." Probably east is equally bad or worse. It is too common to sacrifice the aspect of a house with the object of obtaining a good prospect.

The subsoil upon which the house stands should be porous; retentive soils, or gravels which may be retentive, should be avoided where possible; and where a house *must* be built on a retentive soil, great precaution must be taken effectually to drain the subsoil, and to obviate the dampness of the site as much as possible by the use of concrete. The site must also be so chosen that sufficient facilities shall be secured for drainage and water supply. Shelter should also be secured; this is best effected by trees planted between the house and the points of the prevailing cold or moist winds. It is a bad plan to calculate on steep hills for shelter, as these, in many cases, create currents, which are almost as injurious as the regular prevailing winds. If the house is to be a large one, surrounded by pleasure-grounds, the relations between the house, lawn, and gardens, must be taken into consideration in the choice of site.

Walls.—In the building of walls of all houses, especially those for dwelling in, the first objects to be obtained, from a sanitary point of view, are warmth and dryness. If the walls are too thin, they will be easily affected by changes of temperature, which will not only tend to produce sudden chills of the internal air of the house, but will also produce deposits of moisture on the internal surface when sudden falls of temperature occur, with a previously damp atmosphere. Thus the mere thinness of a wall may produce a damp interior, although the wall may be quite impervious to moisture. Thin walls are *the* great drawback to most modern houses. We think walls should never, under any circumstances, be less than twelve inches thick. With a view of preventing dampness of walls, two points must be attended to—first, to prevent the wall being directly penetrated by drifting rain from the outside; and, secondly, to

prevent the saturation of the wall by ground moisture rising from below. The first object will be attained if the walls be sufficiently thick, well constructed, and of good materials. The surest way of effecting this object, with reasonable economy of materials, is by the use of hollow walls—that is, by, as it were, building two walls and attaching them to one another by ties of brick or iron placed at intervals. This plan is strongly recommended by Mr. Bridgeford, of this city, as the most effective. The intermediate space should be ventilated by perforated bricks. By this means sudden cooling of the inner wall is prevented by the air-jacket placed between the walls, and the possibility of drifting rain permeating to the inside is completely avoided.

To accomplish the second object—namely, to prevent the rising of damp in the walls—many plans have been proposed, but the only effectual one is the interposition of a damp-proof course at some distance above the ground. The distance of the damp-proof course above ground should be such as to prevent the possibility of the wall being wetted above by the gradual accumulation of the soil or gravel of the adjoining flower-beds or walks, and also sufficiently high to prevent much soakage of water from the splashing of rain from the ground in wet weather. Many materials are employed for making these damp-proof courses—bricks set in cement, cement itself, tiles, lead, bricks or tiles set in coal tar, felt, glazed tiles, and asphalt. The last is, we believe, most to be recommended, and is stated to be preferable by Mr. Henderson, in his Lecture on the Construction of Dwellings.[1]

Accommodation.—We have next to consider the amount of accommodation required for each individual or family.

The greater the amount of accommodation the better, provided the size of the house or apartments does not exceed the means of the occupier to maintain the premises in a

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[1] *Lectures on Public Health, Royal Dublin Society.* P. 153.

proper state of repair and cleanliness. The apportioning of accommodation to the means of the inmates is an important social problem which is slowly being solved on economic principles, but which is quite outside the scope of the present work. We cannot altogether avoid moral and social considerations in estimating the proper amount of house accommodation. From a purely sanitary point of view, there is no reason why adult males and females might not sleep in the same apartments; but it is manifest that, as sanitary and moral conditions are closely connected, it is impossible to meet sanitary requirements without at the same time providing the necessary safeguards for morality.

Each family should have at least two rooms—a bed-room and living-room; the latter must be used as a kitchen when the tenement consists of but two rooms. It is impossible for healthy conditions to exist in a single room used for all purposes of eating, drinking, sleeping, and cooking. Two rooms will, however, only afford accommodation at the outside for a married couple with one or two small children. When children grow up, it is absolutely necessary, to secure decency and morality, that the sexes should be separated. Thus, if there are adult children of but one sex, two bed-rooms will become necessary—one for the parents and small children, the other for the adult children. If there are adult children of both sexes, then three bed-rooms are necessary, and the tenement must be increased to a total of four rooms. The sleeping and living accommodation per room must be commensurate with the number of inhabitants, as will be pointed out in the remarks on ventilation we shall make.

Water-closets—House Drains.

Water-closets should be placed in a return building, or built out from the house, and ought to be thoroughly ventilated by windows, etc., and capable of being shut off completely from the house. The soil-pipe running from the

pan should be fully four inches in diameter, and the water supply abundant. One gallon of water is a reasonable quantity with which to flush the pan once. The soil-pipe must be well trapped—preferably with S traps, rather than with the old D form—and then should run directly into the drain. It has been well said, that there are a few simple sanitary rules that can never be transgressed without the infliction of evil, and these rules are :—Whatever pattern of drain pipes be chosen, they should be securely and tightly laid, and in such a manner as to facilitate the removal of waste with all possible speed to a sewer or cesspool. The drain-pipes should run outside, and not through the house, if possible. Well-fitted drain-pipes should be alone used when it is absolutely necessary for the sewage to pass through the house, and then the best form of drain-pipe is made with the "Jennings," which admits of opening at intervals for the removal of obstructions and thorough cleansing, without disturbing the drain generally. This is accomplished by having a length in every ten or twelve feet, made of two semi-cylinders, flanged, so as to lie close, and make a good jointed tube with cement; but yet capable of separation, so that the upper half-cylinder may be removed temporarily, to permit the cleansing of the drain.

Over much trapping of drains should be avoided, but a syphon trap before the drain delivers into the main sewer is usually advisable, in order to check the return of sewer gas.

The possible entrance of the foul air of sewers into a house must be carefully guarded against, and especially when, as in autumn and winter, doors and windows are closed, and fires are burning. Sewer gas may enter a house in any of the following ways :—

"1. It may find admission through the trap of the water-closet when no ventilation has been provided for the soil-pipe of the closet itself. 2. It may enter through defective joints or fissures in the soil-pipe, such defects being the result of bad workmanship, of accident, or decay.

3. Through any pipe that is in direct communication with the sewer, which is for the purpose of conveying away waste of any kind, such as housemaid's sinks, butler's pantry sinks, ordinary kitchen sinks, all baths which communicate directly with the sewer. 4. Through any pipe which is used as an overflow from wash-basins, baths, cisterns, etc. 5. Through the catch-water tray which is placed beneath the usual pan in all expensive water-closets. 6. Through rainwater-pipes communicating directly with the sewer, when they open in enclosed positions or near to open windows. 7. Catch-water drains, which generally exist in cellars and areas under cover, and which are supposed to be trapped by a bell-trap."

All waste water-pipes which deliver into the soil-pipe should be trapped, defective workmanship remedied, and, above all, the soil-pipe ventilated. A good mode of sewer ventilating is to solder to the soil-pipe from the water-closet a leaden tube, about an inch or an inch and a-half in diameter, which is then carried outside the house, and connected with an iron gas-pipe of rather greater diameter, which is carefully jointed, and carried at least *two or three feet beyond the eaves of the house.* The connexion of the leaden ventilating tube with the soil-pipe should be made in the upper part of the syphon, and just beyond (*i.e.*, on the sewer side of) the closet-trap. If two closets are placed one over the other, and delivering into the same soil-pipe, ventilation of the kind we have just mentioned is absolutely necessary, else the flow from the upper closet will untrap the lower one, and permit the free escape of sewer gas into the house. If a bath be placed at the top of a house, a sudden rush of waste water from it, and down the soil-pipe, will also probably have the effect of untrapping the closets delivering into the same tube, unless they are ventilated.

It is scarcely necessary to point out that when there are no water-closets, and privies alone are used, the latter should be placed as far from the house and from any pump-well as possible, and should be cleaned out frequently.

CHAPTER XXI.

AIR AND VENTILATION.

ATMOSPHERIC AIR.—Constituents—a Mechanical Mixture—Reciprocal Action of Animals and Plants upon it—Percentage Composition—Impurities. Ozone. Sulphuretted Hydrogen, etc. Proportion of Carbonic Acid—its Estimation—Pettenkofer's Process—Dr. Angus Smith's Simple Plan. Cubic Air Space required per Head—Principles of Ventilation—Dr. de Chaumont's Conclusions—Effect of Illuminating Materials—Hints on Ventilation.

As an introduction to the subject of ventilation, we may here most conveniently offer a few remarks on atmospheric air. The atmosphere we breathe in large open spaces is liable to singularly little change in the proportions of its chief constituents—oxygen, nitrogen, and carbon dioxide, or carbonic acid. This remarkable regularity in composition of a merely mechanical mixture of gases is due chiefly to the reciprocal action of animals and plants upon it, to the operation of the law of diffusion of gases, and to the influence of air currents. Animals inhale nitrogen and oxygen, but expire nitrogen, carbon dioxide, a little residual oxygen, and aqueous vapour. Plants, on the other hand, inspire carbon dioxide, and, under the influence of sun-light, separate the carbon from it and exhale the oxygen in the gaseous form. Other influences are at work to charge the air with carbonic acid; for example, processes of combustion of heat-producing and of illuminating materials, and the eremacausis or slow decay of organic matters of various kinds; but the effect of vegetation is yet amply sufficient to prevent the gradual accumulation of impurity in the atmosphere.

Air is never absolutely free from carbonic acid in nature, and usually contains about ·04 per cent.; but, when artificially purified from this and other bodies presently to be noticed, the gaseous residue has the following mean composition by weight and by volume:—

	By Volume		By Weight
Oxygen, - - -	20·9	-	23·13
Nitrogen, - - -	79·1	-	76·87
	100·0	-	100·00

As the result of numerous analyses of air collected at various points upon the earth, it may be stated that the variations in the proportions of oxygen are within $\frac{1}{10}$th per cent. by volume, except in tropical countries, where, owing to some hitherto undetermined cause, the oxygen may suddenly drop to 20·3 per cent. The impurities met with in atmospheric air are the floating solid particles—so beautifully seen in Tyndall's tube, or when a beam of sunlight passes through the air—and the gaseous or vaporous bodies: carbonic acid, ammonia, aqueous vapour, and, occasionally, carbonic oxide, marsh gas and other hydrocarbons, sulphur dioxide, or "sulphurous acid," sulphuretted hydrogen, oxides of nitrogen, chlorine, ozone, and "organic emanations" from the lungs and skins of men and animals.

Ozone—so named on account of its peculiar smell—is a very active modification of oxygen, and is produced whenever an electric discharge takes place through air. The most important facts in the chemical history of this curious body, and, indeed, the positive proof of its identity, have been made known to us by the researches of a most distinguished Irish chemist, Dr. Andrews, of Belfast, though it was essentially discovered by Schönbein, in 1840. We possess a very delicate test for this ozone in paper saturated with a mixture of iodide of potassium and starch. When paper so prepared is acted on by ozone, iodine is liberated and its separation evidenced by the strong brown or blue colour developed. It has been long known that when this prepared paper is exposed to pure country air it is quickly discoloured, but it remained for Dr. Andrews to prove that this effect is really due to ozone. Now, it is found that this atmospheric ozone is rarely present in the

air of large towns, more especially in the neighbourhood of factories, and the reason for this clearly is that the organic and other impurities in town air destroy and, we may add at the same time, are destroyed by this ozone, which, therefore, acts as a natural disinfectant in virtue of its extremely energetic oxidising power.

Sulphuretted hydrogen can be easily detected in the atmosphere with the aid of the "lead test paper" described in the Appendix. An atmosphere which causes even slight discoloration of this paper on exposure for ten minutes, must be regarded as positively dangerous.

Of other impurities carbonic acid is the most important to the Sanitary Officer, for two reasons—1st, because its proportion in air may be taken as a measure of the degree of purity of the atmosphere; and, 2ndly, because it is the only usual constituent that admits of easy estimation by any one unskilled in the refined methods of gas analysis. For sanitary purposes we may regard fresh and good air as that containing only ·04 per cent. of carbonic acid. If the proportion much exceeds ·06 per cent., the atmosphere is to be considered unwholesome.

The chemical examination of air by the Sanitary Officer, therefore, involves a determination of the carbonic acid (or, more correctly, carbon dioxide) present in a given volume—the object being to ascertain whether this gas exceeds the proportion of ·06 per cent. The accurate method of Pettenkofer, of Munich, consists in agitating a given volume of air with baryta water, whose power of neutralising a standard solution of oxalic acid is known. The carbonic acid precipitates carbonate of barium, and the excess of baryta remaining in solution is determined by the standard acid. This method is too refined and delicate for use in the course of sanitary inspection; but no such objection applies to the simple and interesting, though approximate, process of Dr. Angus Smith, which we shall now describe.

Dr. Smith finds that half an ounce of perfectly clear lime-

water, when shaken with the air contained in a bottle of 20·63 avoirdupois ounces capacity, does not become turbid, if the air in the bottle contains only ·03 per cent. of carbonic acid; but if ·04 per cent. be present, a white turbidity is produced, owing to the production of calcium carbonate or chalk. A bottle of only 15·16 ounces capacity does not render half an ounce of lime-water turbid when the air contains ·04 per cent. of carbonic acid. Taking this point of "no precipitation" with half an ounce of clear saturated lime-water as the test-point, and varying the bulk of air shaken with it, Dr. Smith has arranged a process which is not only extremely convenient, but gives results sufficiently close to the truth for ordinary purposes—moreover, only great carelessness can lead to serious error, and the necessary apparatus is to be found in every druggist's shop.

It is evident that if calcium carbonate or chalk was absolutely insoluble in plain water or in lime-water, air containing an extremely minute trace of carbonic acid would cause a turbidity; but chalk is sensibly, though very slightly, soluble. Hence, when the carbonic acid in a given bulk of air can produce no more chalk than the half ounce of lime-water used can dissolve, no precipitate or turbidity appears; but when the limit of solubility is exceeded, the excess of chalk separates in the solid form. In the following Table are given the results of Dr. Smith's determinations of the volume of air (at 0° C. and 760 m. m.) containing different percentages of carbonic acid that half an ounce of lime-water will bear agitation with, and yet give no turbidity:—

Size of Bottle, in avoirdupois ounces	Carbonic Acid in Air per cent.
20·63	·03
15·60	·04
12·58	·05
10·57	·06
9·13	·07
8·05	·08
7·21	·09
6·54	·10

Size of Bottle, in avoirdupois ounces	Carbonic Acid in Air per cent.
6·00	·11
5·53	·12
5·15	·13
4·82	·14
4·53	·15
3·52	·20
2·92	·25
2·51	·30
2·01	·40
1·71	·50
1·51	·60
1·36	·70
1·25	·80
1·17	·90
1·10	1·00

It is to be distinctly understood that allowance is made in this Table for the space occupied by half an ounce of lime-water.

The bottles employed may be of clear white glass, and are best stoppered. The lime-water should be delivered into the perfectly clean bottle by a glass pipette capable of measuring half an ounce. When it is desired to test the air of a room, we simply blow it into several of the bottles with a bellows, or a *clean* india-rubber enema bag, and then stopper each bottle. A little paraffin (from a paraffin candle) smeared round the stopper will make it fit closely, and prevent alteration of the air within the bottle.

As already stated, the air of a room ought not to contain more than ·06 per cent. of carbonic acid, and it is often sufficient to ascertain whether the proportion exceeds or falls short of this amount. For the purpose of settling the point, we have only to take a 10-ounce bottle, clean and dry inside, and fill it with the air of the room with the aid of the bellows or syringe; then add half an ounce of clear saturated lime-water, replace the stopper, and shake briskly. If any turbidity appears, we know that the air contains more than ·06 per cent. of carbonic acid.

The amount of air space required for healthy adults in a room is at least 300 cubic feet per head; but it is well to aim at a higher proportion. A room 12 feet long, 10 feet wide, and 10 feet high, contains, when free from furniture and inhabitants, 1,200 cubic feet of air, and will accommodate four healthy adults.

Dr. Parkes gives the following Table of air space allowed to each soldier under different conditions:—

	Cubic feet
In permanent barracks, - - -	600
In wooden huts, - - - -	400
In hospital wards at home, - -	1,200
In hospital wards in the tropics, -	1,500
In wooden hospitals at home, - -	600

But the air requires frequent renewal, and good ventilation consists in the regular removal of impure and the introduction of pure and slightly warmed air, without the production of sensible draught—often a most difficult problem. It may be generally stated that the products of combustion and respiration should be removed from the upper part of a room, since they are at a higher temperature, and specifically lighter than the unused air. The latter should be admitted to the lower part of the room—within a few feet of the floor—and the points of entrance and of exit should be as far apart as possible.

Since an adult expires about sixteen cubic feet of air per hour, and about $\frac{1}{30}$th of this volume is carbonic acid, the air of a room requires frequent renewal in order to prevent the accumulation of carbonic acid. We shall now cite the conclusions of Dr. de Chaumont upon this important point (quoted in Dr. Angus Smith's valuable work "On Air and Rain"). De Chaumont says:—

"1. We cannot safely accept a lower standard [of purity] than ·06 per cent. of carbonic acid.

"2. We cannot legislate for anything short of uniform diffusion in air space.

"3. Uniform diffusion being supposed, we cannot preserve our minimum standard of purity with a less delivery of fresh air than 3,000 cubic feet per head per hour.

"4. We cannot safely change the air on an average oftener than six times in an hour without producing draught.

"5. With ordinary means of ventilation we can seldom hope to succeed in changing the air even six times in an hour.

"6. We cannot provide an air space which will admit of the delivery of 3,000 cubic feet per head per hour, and at the same time preclude the necessity of changing the whole air as often as six times per hour.

"7. *To fulfil all the above conditions, a minimum of* 1,000 *cubic feet per head per hour is absolutely necessary.*

"8. To provide the supply of 3,000 cubic feet, so that the velocity of the current at the point of entry should not exceed 5 feet per second, 48 square inches of total inlet and outlet area ought to be provided, and this independent of the chimney, if there be an open fireplace."

Illuminating materials also use up air. The ordinary gas burners consume about 3 cubic feet of coal gas per hour, and this quantity of gas (or an average of about 5 ounces of oil or fat) render about 3,600 cubic feet of air impure. An ordinary three-foot gas burner, therefore, uses up more air than three grown-up persons.

Having so far stated the principles to be acted upon, we may now offer a few hints on modes of ventilating.

If the construction of a house admits of it, we may advantageously keep a skylight or attic window always open for general ventilation. Fresh air may be easily admitted to halls or rooms without producing unpleasant draught, by placing under the lower window-sash a slip of wood, plain or covered with baize, and about one and a half inches thick. The sash rests upon this instead of its usual bed, and prevents any air from entering directly; but a space is

thereby left between the upper and lower sashes through which external air is admitted to the room, and on entering receives an upward direction, and is slightly warmed.

Arnott's ventilator gives egress to foul air, and either communicates with the chimney or with the external atmosphere. It consists of a balanced valve, which easily opens by pressure from within the room, but flaps to when a current of air attempts to pass in the opposite direction. This simple and useful form of ventilator is placed near the ceiling. It often causes an unpleasant noise, even when muffed with corks, and allows a little smoke to blow into the room occasionally when it is connected with the chimney; but it has the advantage of drawing off the impure air from the upper part of the room.

Dr. Chowne's syphon ventilators are tubes reaching from the top of a room, and then carried down for a few feet and passed into the chimney, which acts as the longer leg of an inverted syphon.

M'Kinnell's ventilator consists of two tubes of unequal diameter. The narrower tube is longest, and passes through the wider one—which is attached to the ceiling—leaving a considerable air space between. The narrow tube has a wide flange at the end within the room, by which the air entering between it and the wide tube is thrown off against the sides of the room, and is warmed. The up-draught of warm and impure air is through the long tube.

A very simple mode of providing entrance for air at a height of about 7 feet from the floor, is to make an U-shaped air passage within the architrave of the door of a room, by cutting away the plaster on both sides of the wall flush with the woodwork, the latter then serves as a casing, and the air passes between the wood and the brickwork.

Ventilating gas lights are also effective; a "sunlight" especially, since products of combustion and heated air are alike drawn away in the rapid current produced; but it is necessary to provide valves for the tubes giving exit to the

products of combustion, else when the gas is not lighted an unpleasant down-draught is liable to set in.

It is always desirable, when possible, to make special arrangements for carrying away the products of combustion of illuminating materials, and this can be accomplished with ease for gasaliers by having a long tin tube, provided with a funnel-shaped opening over the gas jets, carried between the joists above the ceiling, and communicating with the open air. This plan is often employed with advantage in public buildings, and might be much more freely used in private houses than it is at present.

The examination of wall papers for arsenic is described in Appendix II.

CHAPTER XXII.

Sewage and its Treatment.

Sewage.—Construction of Town Sewers—House Sewage. Deodorising—Moule's Earth Closet—Charcoal Closet. Cesspools—Water-carriage. Deodorising House and Town Sewers. Treatment of Town Refuse—Precipitation in Tanks—Irrigation with Effluent Water—Sewage Farms.

The average amount of excreta produced by five persons in a week is about $5\frac{1}{2}$ lbs. of solid and 9 gallons of liquid matter. The economical disposal of this and other house refuse constitutes one of the most perplexing problems for the sanitarian, and is one which has not even yet received a very satisfactory solution. Our chief mode of removing town sewage—namely, that by water-carriage—is about as wasteful a plan as can well be conceived, when we recollect that undiluted sewage is a valuable manure, while the largely diluted sewage is of vastly less practical value than many social economists seem to think. But so essential to the health of the inhabitants of a town do we consider the rapid removal of its sewage, that we are not only willing to waste the manure, but we go to great expense in order to secure its almost reckless dissipation. However, the "sewage question" is far too extensive to be fairly dealt with in the single chapter we can find space for, or even in a volume of moderate size.[1] Hence we shall treat in this place only of those points which are of immediate importance to the Sanitary Officer.

The construction of conduits for sewage, or sewers, falls specially within the province of the engineer; but it is desirable that the Sanitary Officer should insist that ample provision be made in the construction of new street sewers against soakage of sewage matter from the main drains

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[1] We may refer the reader for full information to Dr. Corfield's "Treatment and Utilization of Sewage," and to a useful work on the "Sewage Question" published by Ballière.

through the adjacent soil; that a good fall be secured; that street-channel drains be well trapped, and proper ventilation of the main sewer provided.

The most convenient and practical division of our subject is into the disposal of sewage from (*a*) one house or from a few close-lying houses, and (*b*) from a town of considerable size.

(*a.*) *Refuse from one or from a few adjacent houses.*—When privies are used, the liquid sewage is often allowed to percolate through the soil, and to contaminate neighbouring wells, while the solid excreta remain and decompose, thereby producing most offensive smells. In Paris the solid matter is rapidly drained, removed at short intervals, and quickly dried, forming "*poudrette;*" but in this country the offensive matter is often left for months in a moist and putrescent state. The primary object of the Sanitary Officer, in dealing with such a case, is to deodorise and check decomposition. These ends may be most conveniently secured by sprinkling with a solution of copperas (ferrous sulphate) or the mixture of copperas and blue vitriol (cupric sulphate) we describe in the article on *Disinfection.* Some fresh earth may then be thrown over the mass, and the escape of bad smell thereby prevented until the offensive matter can be carted away, and applied as manure. When a primitive privy of this kind must be used, fresh earth and wood ashes or charcoal are the most convenient deodorants and absorbents we can employ; but privies of this kind should be frequently cleared of refuse.

When a very absorbent earth is used in a dry, well-sifted condition, and in much larger proportion than is contemplated in the foregoing paragraph, we may have a closet within a house according to the plan of the Rev. Henry Moule, Vicar of Fordington. In Moule's earth closet about 1½ lbs. of suitable earth is thrown over the excreta each time the closet is used; the mixture of earth and excreta is removed, allowed to dry in a pit protected from rain, and then can be used over again. The great difficulties in the way of the use of the earth closet are the provision of proper material, its drying and sifting, and the removal of the

bulky manure produced. These objections have, however, little force in a country house. Charcoal, especially that from seaweed, has been used by Mr. Stanford with success as a substitute for earth, and is superior to all other absorbents in disinfectant power. According to Mr. Stanford—

"It only requires one-fourth the quantity as compared to earth, and, by re-burning the charcoal, the supply is provided from the excreta itself; and the cartage is reduced to the weight of the material carried into the city, and twice its weight carried out. The quantity per diem for a population of 500,000 is calculated at 385 tons in, and 770 tons out; a quantity about the same in Glasgow as the city ashes.

"Moreover, charcoal has other advantages over earth. It is a powerful deodoriser, and its employment guarantees a perfect immunity from odour quite unattainable by any water-closet; and it blackens and conceals the excreta so perfectly that no one seeing the product from the closets for the first time would have the least notion from its appearance what it was."

It is well to add that the charcoal required for each closet, when used by six persons each day, is stated to be about 1 cwt. per month. Suitable charcoal is estimated to cost about £2 per ton, and when it has been repeatedly used and dried, one ton of the manure is said to be value for £4. These statements must, however, be received with much reserve.

We turn now to the consideration of another variety of privy or closet—*i.e.*, that connected with a cesspool or "dumb well." In these the excreta are made to pass into a drain, and thence into a covered reservoir. The soil is either allowed to gravitate into the cesspool, or is carried along by a current of water. The former plan is sometimes used in common out-privies, the latter in house water-closets not connected with a system of street sewers. In country places the cesspool usually can and ought always be placed at a considerable distance from the house, and from any wells for the supply of water. In towns it is rarely possible to have cesspools far from a house or well; a cesspool then causes serious mischief, either by permitting soakage of sewage matter into the soil beneath the house, and the ascent of

gaseous impurities, or by contaminating the well; and, finally, we have the tank containing a quantity of pasty, putrescent matter, which is constantly emitting noxious gases and vapours. The latter nuisance can be much diminished by covering the cesspool with a perforated frame, upon which is piled a quantity of charcoal; but the evil attending soil percolation—an evil increased when water-closets deliver into the tank—cannot be avoided, unless we construct cesspools with impervious bottoms and sides, and take care that they are emptied frequently, the contents being partially deodorised by clay or charcoal, carted away and applied as manure.

The storage of animal excreta in cesspools near to houses and wells is to be regarded as the most dangerous of all modes of temporarily disposing of sewage, and is attended with exceptional risk when the water supply is drawn from a well in the neighbourhood of the sewage tank.

The water-carriage system, by which the sewage is swept through carefully constructed drains out of the house into the street sewer, is undoubtedly the most convenient and least dangerous plan, though, as we have already stated, it is the most wasteful method. A well-constructed and ventilated water-closet, connected with a good general sewerage system, ought not to cause any unpleasant smell in a house; but should deodorants be required, in the opinion of the Sanitary Officer, liquids alone ought to be employed, and these such as cannot exert a corrosive action on the leaden or iron tubes, or metallic apparatus of the closet. Condy's fluid is an exceedingly convenient deodorant for this purpose, or a mixed solution of the sulphates of copper and iron, solution of alum, of chloralum, of sulphate of zinc, sulphite of lime, carbolic acid, or of nitrate of lead, may be employed, but acids and chloride of lime are objectionable.

Town sewers may be conveniently deodorised and disinfected by means of chloride of lime, chloralum, perchloride of iron, the sulphites, or carbolic acid. When sewer gas escapes from badly-trapped channel drains, or from other

openings, the plan of Dr. Stenhouse should be adopted, of obliging the issuing gas to pass through a layer of wood charcoal. This is laid in trays, and covered, so as to be protected from wet. These air-filters are very effective, and last for a long time.

(*b.*) *Treatment or Disposal of the General Refuse from a Town.*—Whether the town sewage is removed by carting from cesspools into suburban tanks, or the refuse is carried there by water, the Medical Officer will have to advise as to the final treatment, unless it is immediately discharged into the sea. In the latter case no special treatment is necessary, unless it may be deodorisation, and this is always best accomplished in the cesspools or the sewers by the addition of any of the agents we have above enumerated.

But it may not be possible to send the refuse into the sea, or even into a river. In such a case the general plan which, according to our rather large experience in the matter, is almost invariably applicable in a more or less modified form is the following:—Prepare a crude sulphate of alumina by acting upon every 2 cwt. of a *dry* and highly argillaceous clay with 1 cwt. of strong oil of vitriol. The mixture must be thoroughly effected by means of thick iron shovels, though the acid will act upon the metal. Let the mass stand for ten days or a fortnight, in order to render the action as complete as possible. Then, in order to treat 100,000 gallons of sewage, place in the bottom of a tank capable of containing this bulk of liquid 1½ cwt. (or 2½ cwt. if the sewage be very strong) of the sulphated clay. The latter is then stirred up with 100 gallons or so of water, in order to get as much sulphate of alumina as possible into solution. The sewage is then pumped, or allowed to flow in. When the 100,000 gallons have been delivered, the mixture is stirred with long poles, and the whole allowed to rest for some hours. The alkaline sewage precipitates the alumina from the sulphate, and this, in falling to the bottom, carries with it suspended matters, leaving a clear liquid, usually almost inodorous. The patent process of Anderson differs from the above only

in the addition of lime to the mixture of sulphated clay and sewage. When complete separation has taken place, the clear liquid is run off from the tank, without disturbing the precipitate, and the latter collected as a mud, and allowed to drain on a porous bed, then kiln-dried, and sold as manure, its manurial value being about thirty shillings a ton; or it may be burnt, and the residue used for making another quantity of sulphated clay.

The treatment of the clear liquid has now to be considered. This solution contains most of the urea present in the sewage, since this is a very soluble body, and is not precipitable by any known process; moreover it is the constituent of the sewage of highest manurial value, on account of the large proportion of nitrogen it contains. Though we are not able to precipitate this urea from the effluent water from our tanks, percolation of the liquid through soil serves to remove it in great part, since it is easily decomposed into ammoniacal compounds, which the soil retains with extraordinary power, while a portion of the constituent nitrogen is oxidised to nitrous and nitric acids during the passage of the water. The best mode of disposing of the effluent water from the precipitating tank is by irrigation over land, for all offensive matter has been removed from the sewage, and the water distributed does not create a nuisance. The land irrigated with the effluent water yields good crops on cultivation, and is unobjectionable as a "sewage farm." Our experience of the Edinburgh and the Croydon farms, where untreated sewage is distributed, is such as to lead us to recommend the above-described precipitation of offensive solid matters in tanks prior to the flooding of land with the liquid.

It may be asked, Can the effluent water from the precipitating tank be allowed to flow into a river? We say, Certainly not before it has percolated through a stretch of rather porous soil, and so undergone another and most important purifying process. After sufficient filtration of this kind, it may be allowed to flow into a relatively large and rapid river.

CHAPTER XXIII.

Contagion and Disinfection.

Theories of Contagion—Gaseous and Zymotic Hypotheses—Contagion Particles—Chauveau's Experiments on Vaccine Lymph—Chemical Agents used as "Disinfectants"—Deodorants—Antiseptics—True Disinfectants—Treatment of Excreta, etc.—Disinfection of a Room—Chemical Treatment of Articles of Clothing—Disinfection of Bedding, Clothing, etc., with the aid of Heat—Dry Heat—Steam Chamber for Disinfection.

Dr. Burdon Sanderson, in the introductory remarks to his report "On the Intimate Pathology of Contagion," says:—"The question of the mode of existence of contagious matter lies at the foundation of all scientific inquiry as to the means of obviating or counteracting contagion." It is, therefore, advisable to devote some attention to the consideration of contagion before referring to disinfection, or the destruction of contagion.

Many and contradictory opinions have, from time to time, been held with regard to the intimate nature of contagion. The oldest view appears to have attributed it to the effect of poisonous gases inhaled or absorbed, or to the poisonous effects of putrid animal or vegetable matters. This view was closely connected with the *zymotic* theory of contagion; for some believed that these poisonous gases, etc., acted not as *direct* poisons, but by setting up changes which gave rise to *specific* poisonous effects.

The more recent *zymotic* view was that a certain ferment was introduced into the body, which produced a peculiar form of fermentation, differing for each different disease. This ferment acts until the substance capable of being acted upon is exhausted, or its action put a stop to by some external agent. Neither of these views is held to any great extent by scientific pathologists of the present day, and in their

place has been substituted the hypothesis that the contagious particles of disease are living organisms. Dr. Sanderson says:—

"The notions which at present float in the minds of the medical community as to the nature of contagion are vague and indefinite. They are, for the most part, derived from what is commonly observed as to the mode of communication of small-pox and cow-pox. As regards the latter, it is held by almost all experts in vaccination that vaccine is a transparent liquid, and that it is most active when most transparent; whence it is most natural to infer that the contagious principle is soluble. As regards variola, it is known that the morbific influences can be exercised at a distance from their source, and through the air. From this undoubted fact it is assumed, almost as if it followed from it, that the infective poison is volatile, and that it possesses the physical properties of a vapour."

Dr. Parkes makes a very practical classification (under three heads) of the various views at present held with regard to the nature of contagion, as follows:—

1. The particles are supposed to be of animal origin, born in and only growing in the body; they are, in fact, minute portions of *bioplasm* or *protoplasm*.—(*Beale.*)

2. The particles are supposed to be of a fungoid nature, introduced *ab externo*.

3. The particles of contagion are thought to be like *Schizomycetes*, *i.e.*, of that class of organisms which Nägeli has separated from fungi, and which form the lowest stratum of the animate world at present known to us. These bodies have the various names—Bacteria, Zoöglœa, Microzymes, Vibrios, Monads, etc.

The observations and experiments of Dr. Sanderson and others "afford strong ground for accepting the doctrine . . that the contagious principle is neither soluble in water nor capable of assuming the form of vapour;" but, in making this statement, Dr. Sanderson should not be understood to convey the impression that contagia may not be carried mechanically by either air or water as dust or sediment, for, in fact, these methods for the conveyance of contagion are proved to exist.

As to the nature of the contagious particles, they are, probably, colourless bodies, differing but little, if at all, from the fluid containing them. Thus, for instance, fresh, pure vaccine lymph appears as a colourless, homogeneous fluid. The particles must be extremely small, as the most minute portion of a contagious fluid will carry the infection. A proof of the minuteness of the particles of contagion is that M. Chauveau has ascertained that vaccine matter may be diluted ten times, and the contagious fluid of sheep-pox many hundred times, without destroying its activity. Chauveau's experiments also "furnish strong additional evidence in support of the doctrine that contagium consists of particles. They show that, whatever may be the degree of dilution, the local effect produced is always the same."

"If contagium is alive, it may be so in one of two senses, either as a part of the living body, which is the seat of the disease, or as in itself a living organised being inhabiting the diseased body. If it is not alive, its action must be chemical."

It is probable that the action, if chemical, is of a complex catalytic character; it must, however, be admitted that the evidence is on the whole most favourable to the view that contagium is a living thing, but under which of the three heads, as given by Dr. Parkes, the true explanation is to be found we are at present ignorant. Contagium then is to be treated as a living thing, and any agent which is incapable of destroying the lowest forms of organic life cannot be expected to act as an efficient disinfectant.

The general term "DISINFECTANT" is often held to include three classes of chemical agents—in addition to the physical agent, heat. I. Bodies which remove bad smells, or *deodorants*. II. Substances which check, or wholly prevent, decomposition, or *antiseptics*. III. Bodies which exert a destructive action upon minute living organisms, and upon dead organic matter, or *true disinfectants*.

I. The chief DEODORANTS are—charcoal in its various forms, especially when freshly burned, chlorine gas (evolved by the

action of any acid, such as vinegar, or "chloride of lime"),[1] chloride of lime, or bleaching powder, "bleaching soda," ozone, permanganate of potassium, chromic acid, nitrate of lead, sulphates and chlorides of iron, copper, and zinc, peroxide of iron, peroxide of manganese, and earth. Most of these bodies deodorise in virtue of their powerful oxidising action; this is especially true of chlorine, "bleaching powder," "bleaching soda," ozone, permanganate of potassium, and charcoal. The last-named substance acts also as an absorbent for offensive gases—a property which it shares with common dry earth. The efficiency of nitrate of lead is chiefly due to the readiness with which it fixes the sulphur of sulphuretted hydrogen and of certain other sulphuretted bodies, producing inodorous sulphide of lead, and thereby destroying the offensive smell. Solutions of the sulphates of copper, iron, and zinc, the chloride of the latter metal (Sir William Burnett's disinfectant fluid), and perchloride of iron act in a similar manner, and serve also to remove ammoniacal odours. It must be distinctly understood, however, that the removal of a bad smell can in no sense be regarded as evidence of true disinfection, at the same time many of the bodies which act efficiently as deodorants, *e.g.*, chlorine, ozone, and some of the metallic salts, are believed also to act as true disinfectants, or as antiseptics.

II. At the head of the group of ANTISEPTICS—bodies which check or wholly prevent decomposition—we may place carbolic, cresylic, benzoic, picric, and chromic acids, sulphur dioxide, or sulphurous acid, creasote, camphor, turpentine, etc., while the metallic sulphites, alum, "chloralum," metallic sulphates, especially copper sulphate, the ordinary mineral acids, and the alkalies are also effective though the latter are less powerful

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[1] A steady supply of chlorine gas is conveniently obtained on warming a mixture of one part common salt, one part finely powdered black oxide of manganese, and two parts of oil of vitriol, previously diluted with twice its bulk of water.

in their action. Many of these bodies, particularly those first named, not only check decomposition in a very remarkable manner, but also appear to destroy the vitality of those microzymes, supposed to resemble the living contagion particles.

III. Of TRUE DISINFECTANTS, the most effective are those bodies which possess very powerful oxidising properties, such as chlorine, the oxides of nitrogen evolved on treating metallic copper with moderately strong nitric acid, ozone, iodine, nitric and chromic acids, and the permanganates.

Numerous though the substances are that we can employ for purposes of disinfection, we are practically limited in our choice by considerations of economy, convenience, and efficiency, for it must be borne in mind that effective disinfection cannot be expected to result from the use in small quantity only of the most powerful agent known. Hence the substances employed must be obtainable with facility in considerable quantities, and must be comparatively cheap.

In dealing with a case of contagious disease, it is always desirable to pursue the general plan of disinfection we shall now sketch, even though the Sanitary Officer may not place great confidence in the use of agents whose contagion-destroying power is quite open to question.

The patient's stools and vomited matter should be immediately treated by free sprinkling with a roughly-powdered mixture of four parts of common sulphate of iron (copperas) and one part of sulphate of copper (blue stone). If necessary, a little water may be thrown into the vessels, in order to facilitate solution of the salts. All articles of clothing, however trifling, pieces of cloth, books, toys, etc., used by the patient, should be set aside, the worthless articles and those of little value to be burned as soon as possible, and the clothing, etc., to be treated as we shall describe further on. Of all the bodies used to "purify" the atmosphere of a sick chamber chloride of lime, made into a paste with water, and spread on plates is, perhaps, least open to objection. If the smell proves disagreeable to a patient, "Condy's fluid" may be substituted, though the non-volatility of the active ingredient

(permanganate of potassium) renders it less effective. It is well to remember that, when used in this manner, both the above-named bodies probably act only as deodorants. Perfect cleanliness in the sick chamber and good ventilation are of vastly greater importance than the use of any known disinfectant that could be safely employed under the circumstances. But, if it be desired to try general disinfection, we decidedly give the preference to the occasional burning of ordinary incense, mixed with about one-sixth of its weight of benzoic acid, in different parts of the house, while carbolic or, better still, cresylic acid may be used in water-closets, etc. At the termination of an illness, the room or rooms occupied by the patient should be cleared of furniture, carpeting, curtains, etc., the paper removed from the walls, the chimney stopped, and windows well closed. A *large* earthenware basin is then placed in the centre of the room. If the apartment be of moderate size, put half a pound of copper wire, cut in short pieces, into the basin, and pour upon it three times its weight of aquafortis (strong commercial nitric acid) diluted with its own bulk of water. Action speedily commences, and ruddy fumes are evolved, consisting of oxides of nitrogen. The door of the room is now carefully closed, and not opened for a few days; then a shovel, containing a few pieces of red-hot coal, is brought into the room, and two or three ounces of sulphur thrown on the coals. The sulphur burns, and produces abundance of sulphur dioxide, commonly called sulphurous acid; the door is again secured. After a day or two the room may be entered, the windows thrown open, the ceilings whitened, the walls papered, and the woodwork and floors washed with water containing a teaspoonful of benzoic acid per gallon.

Articles of clothing which will admit of the treatment should be boiled with water first, and then be steeped for some days in fresh water, containing benzoic acid in the proportion of a large teaspoonful of the common acid for every five gallons of water. Let the articles then be boiled in the steep-water, and next washed as usual.

Although the best and safest course unquestionably is to burn all clothes, bedding, hangings, etc., we may attempt the destruction of the contagion particles by heating to a much higher temperature than that of boiling water, though not to such a temperature as to destroy the material operated upon. The temperature of 260° F. is about the highest that ordinary fabrics can bear for any length of time, and this heat may be applied by enclosing the articles in a large oven of brick or iron, raised to the required temperature by a coil of metal pipe, through which more or less of the hot gases from a small furnace can be directed, according to the temperature desired. The precise degree can be determined by a thermometer, whose stem passes through the door of the chamber. A tube should convey the effluvia of the clothes from the upper part of the oven to the ashpit of the furnace, in order that the gaseous or other exhalations may be burnt, and so prevented from polluting the atmosphere.

It is comparatively difficult to regulate the temperature of a large chamber heated in this way, or to ensure the thorough treatment of the articles enclosed in it. We should much prefer to use several small steam-tight chambers, and to connect them directly with a boiler. The steam should be allowed to pass freely into each disinfecting chamber, from which it might issue at a pressure of about 20 lbs. A temperature of 230° F. is supposed to destroy all living organisms; but a temperature of 250° F. can be easily reached and maintained economically by the steam under pressure, and since the heat is also more evenly distributed in the steam than in the air chamber, we give the preference to the former. The time during which articles must be subjected to a high temperature varies with the thickness of material, and the facility with which it conducts heat. It is usual to leave such articles as pillows in the hot-air chambers for as much as five or six hours. We need scarcely add that every town should be provided with at least one chamber for disinfection with the aid of heat.

CHAPTER XXIV.

Accommodation for the Sick.

Departments of Hospital Establishments.—Conveyances for the Sick.—Ambulances.—Two kinds of Ambulance necessary.—Disinfection of Ambulances.—Hospitals.—Reception of Sick.—Hospital Wards.—Size and Accommodation in Wards.—Warming, Ventilating, Lighting, and Decoration of Wards.—Ward Offices.—Pavilion Hospitals.—Cottage Hospitals.—Epidemic Hospitals.—Intercepting Hospitals.—Floating Hospitals.—Lying-in Hospitals.—Refuges for Persons exposed to Infection.—Quarantine and Sanitary Inspection of Shipping.

The duty of providing accommodation for the sick is vested in the sanitary authorities of the district.

Hospital establishments must be considered to consist of three principal departments—

1st. That for bringing the patient to and admitting him into the hospital.

2nd. That for his proper accommodation in the hospital during the treatment of his disease.

3rd. That for his accommodation after treatment and during convalescence.

Conveyances for the Sick.—The conveyance of the sick to hospital is one of the most important duties which a sanitary authority has to perform. Every sanitary district should be provided with a sufficient number of properly constructed ambulances for the conveyance of the sick; these should be placed in easily accessible positions, and should be quickly available at all hours, otherwise the public will at once lose confidence in their management, and make use of other vehicles for the removal of the sick. Every facility and encouragement should be given for the use of these ambulances. No charge should be made, and the most scrupulous care should be exercised by the persons in charge of them. It would be out of place to

describe minutely a particular form of conveyance, but one thing must be positively stated, that none of the ordinary private or public vehicles are suitably constructed for the purpose, and few of them can even be modified so as to make comfortable or efficient ambulances. Nothing is to be more deprecated than the system so commonly pursued at present of using (either modified or unmodified) old worn out cabs or carriages. The conditions necessary for an ambulance are, that the patient can be conveyed from his own bed to the ambulance in a recumbent position, and without change of position—in other words, the couch of the ambulance should be capable of being brought to the patient's bedside, then replaced in the ambulance, and on arrival at the hospital carried at once to the hospital bedside. The patient should be easily accessible when in the ambulance, and the vehicle should be lightly and efficiently springed, so as to avoid any shaking.

Every sanitary authority should maintain two sets of ambulances, one for persons suffering from contagious diseases, the other for ordinary cases. The ambulance used for contagious diseases should be disinfected after each time it is used, so that it may not be a means of spreading diseases.

Hospitals.

Hospitals are of various kinds, according to the various conditions to be fulfilled, but the general principles of construction may be the same for all. The main points to be carried out in an hospital are to combine, as far as possible, the conditions of economy of administration with sufficient provision for attendance, cleanliness, ventilation, water supply, and medical attendance. The site of a hospital must depend, to a great extent, upon the locality for which the institution is intended. It should be built as far as possible from other dwellings, on a pervious soil, sufficiently high to afford proper drainage, and plenty of sunshine, and a plenti-

ful and pure water supply. It is generally considered that a hospital of 80 or 100 beds should stand on at least one acre of ground, but this should not satisfy the managers if a larger space can be obtained.

Reception of Patient.—There should be a special reception-room for the patients in every hospital. If the case be a bad one, the patient should be placed in his bed *in this reception-room.* The patient's own clothes should be taken off in the reception-room, and be disinfected if necessary, and conveyed to a proper store. The patient's own clothes should never be permitted to be taken into the wards. The patient should be washed and made tidy if possible in this reception-room, which should be provided with a bath and other means for cleansing dirty patients.

Hospital Wards.—The unit of a hospital is *the ward*, and having determined the arrangements necessary for a single ward, the question of their combination into a hospital is a simple one. The maximal number of patients to be accommodated in a ward is chiefly determined by the number which can be efficiently supervised by one head-nurse, as it is impossible that one nurse can supervise patients in different wards at the same time. The number of cases capable of being supervised by one head-nurse is from 25 to 30, according to the nature of the cases.[1] A ward should, therefore, be constructed for the accommodation of not more than 30 beds. The size of the ward must be regulated by the superficial and cubic space required for each patient. The width of the ward should be from 25 to 30 feet, its height from 12 to 14 feet, its length to be determined by the number of patients to be accommodated. Each bed should have a space of 7½ feet along the wall, and there should be 10 feet between the opposite rows of beds. There should be at least 90 superficial and 1,000 cubic feet of space for each bed in ordinary wards, and this space should be doubled for the

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[1] Nightingale's *Notes on Hospitals and Nursing.*

treatment of contagious diseases, operation, or lying-in cases. In other wards for diseases belonging to the zymotic or erysipelatous groups, the wards should either be double the size (which would be inconvenient), or but half the number of patients should be placed in the ward. A hospital ward should have windows upon both sides, and if possible at one end there should be a window for each bed and placed between them; it should open top and bottom; the top should reach nearly to the ceiling, and the bottom within two feet of the floor, so that the patients will be able to look out; it should be glazed with thick plate glass, so as to avoid sudden changes of temperature, and prevent loss of heat; there should be *one* square foot of window surface for each fifty feet of cubic space. The walls and ceiling of the ward should be covered with impervious cement or glazed tiles, and if these are not obtainable they should be painted and varnished so as to be capable of being easily washed. The floors and woodwork should be of wood, as impervious as possible, and polished—the floor with wax—capable of being cleaned by rubbing with a damp cloth. Polished pine will be found best for doors, windows, and door casements, and oak or parqueterie work for the floor.

Warming.—This is best accomplished by open grates, their advantage consisting in cheerfulness and better means of ventilation. Hospital wards should be as far as possible kept at a constant temperature, registering thermometers to be placed in each ward under lock and key, for the information of the superintendent. Hot-water pipes or stoves are sometimes employed for warming hospitals, but are inferior to properly distributed open fireplaces. In large hospitals, however, stoves or hot-water pipes may be used with great advantage in warming halls, passages, etc.

Ventilation.—Two systems of ventilation are spoken of—namely, natural ventilation by windows, doors, and chimneys, and artificial ventilation by ventilating shafts, fire places, or gas lights. Each is good in its own place, and should be

combined, as in this climate ventilation by open windows is frequently unbearable. Each patient should have 3,000 cubic feet of fresh air per hour. If ventilating shafts are used, there should be an opening of one square inch for each 50 cubic feet of ward space in upper floors, 1 for 55 in the next or middle floor, and 1 for 60 in lower floors, for exit of impure air. For the admission of air there should be one square inch for every 100 cubic feet of ward space.[1]

Lighting.—There should be plenty of daylight; this will be provided if the windows are distributed as recommended above. At night the wards may be lighted by gas, lamps, or candles, according to circumstances.

Where gas or lamps are used, great care should be taken to carry off the products of combustion. There are many forms of gas fittings by which all products of combustion are conveyed out of the room, and these fittings have the great advantage of assisting ventilation.

Decoration.—Although ornamentation of wards is not a necessity, yet it is a great advantage; it should not be accomplished by ornamental plaster or woodwork, which only impedes ventilation and collects dirt, but by means of plants, flowers, and pictures. Such ornaments add much to the cheerfulness of the wards, thereby promoting the recovery of the patients.[2]

Ward Offices.—Each ward should have attached to it nurses' rooms, a water-closet, bath-room, and scullery, together with proper drainage for slops, etc. Each ward should have a constant and unlimited supply of hot and cold water by day and night.

Pavilion Hospitals.—If the above form of ward be adopted, the hospital must be constructed on the pavilion principle, which is, that each ward, or block of wards, is completely isolated from the rest of the hospital, and connected therewith only by corridors, which, in our opinion, should be

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[1] Galton *On Hospital Construction.*
[2] Acland *On Hospital Decoration.*

open to the air. A pavilion never should be more than three stories high; and where ground is easily obtainable, it should be only one story high. The pavilions where there are more than one story should be separated from one another by a space equal at least to twice their height. In general hospitals the pavilions for medical, surgical, and contagious diseases, should be separate buildings. The smallest general hospital, therefore, should consist of at least three blocks of wards, each block being but one story high. The administrative department likewise should have a block to itself, containing board-room and apartments for the resident officers, etc. In addition to the large wards, each hospital should have several small wards for the accommodation of cases requiring isolation. The plan of supplying hospital accommodation for villages by means of what are termed "Cottage Hospitals" has, within the last few years, met with great success in many villages in England.

The general principles to be followed are the same as for larger buildings, but they should seldom be constructed for more than a dozen patients; the wards should be miniature pavilions, and may be combined in any number according to the circumstances of the village. Cottage hospitals are specially applicable to a country like Ireland, where there are many small towns and villages remote from workhouse hospitals or county infirmaries.

Epidemic Hospitals.—These are intended for use in times of epidemics, and may at other times be used for the treatment of contagious diseases.

It has been too much the practice to provide for epidemics by the erection of temporary buildings; this is an objectionable practice, not only from the buildings being temporary, but because their construction is usually not commenced until the epidemic has established itself, and the disease has spread more quickly than the hospital accommodation can be provided to meet it. This has unfortunately been exemplified in almost every epidemic which has visited Ireland.

Every Sanitary Authority should provide an epidemic hospital for its district, the accommodation in it being equal to that of an ordinary hospital; that is, one hospital bed for

every 200 people in town, and one for every 400 in country districts.

Intercepting Hospitals.—Port sanitary authorities are bound to provide hospitals for the reception of persons labouring under contagious diseases who may arrive in ships from infected ports. These hospitals may be either floating or situated on land in an isolated spot near the port—the latter is preferable. There will almost always be some suitable piece of land for the building of a port hospital, and extensive powers are given under the Public Health (Ireland) Act, 1874, for acquiring such sites. Floating port hospitals may be either built specially, as is the case in the port of Dublin, or a ship may be fitted up for the purpose.[1]

When a floating hospital, however, is employed, special arrangements should be made for the conveyance of the sick to the hospital from the infected vessel. A bed, capable of being swung from the ship to the boat, and again lifted into the hospital ship and lowered at once into the ward, through a hatchway, should be provided in connexion with each port hospital.

Convalescent Homes.—Accommodation should be provided for convalescents from all forms of disease, but specially for those who have suffered from contagious zymotics. Convalescent hospitals are advantageous and necessary in many ways; they aid in restoring health to the patients, rendering them able to return at once to their employment, thus preventing their future ill health and its resulting pauperism. Nothing tends so much to promote chronic disease as returning too soon to ordinary work after an acute illness. In contagious cases it is most important to retain patients in a convalescent hospital for some time after the subsidence of

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[1] Floating hospitals are objectionable on many grounds. The motion of the vessel in stormy weather, even in the most sheltered spots, is calculated to injure the patients and render communication with, and removal of, patients to and from the hospital difficult; and it is more difficult to carry out sanitary arrangements on sea than on land.

the disease, as a preventive measure and for the safety of the public; for many epidemics, such as small-pox and scarlatina, are kept up by the patients leaving hospital before they are free from contagion.

Hospitals for Incurables.—These must be more of the nature of asylums for the aged and infirm than of hospitals for those who are usually looked upon as sick. In fact, hospitals for incurables can scarcely be classed among hospitals, but are necessary and valuable charities, and deserve encouragement; they should not, however, be confounded with true hospitals, which are meant for the *cure* of the sick.

Lying-in Hospitals.—It should be the duty of sanitary authorities to make provision for lying-in women. The *general* principles of construction are the same for lying-in hospitals as for others; but certain special provisions must be made in them. The patients should be delivered in a separate ward from that in which the after-management is carried out. Only one woman should be delivered at a time in the ward, so that for a large number of cases more than one delivery ward should be maintained. It is generally considered that not more than four parturient women should be permitted to remain in one ward, and many even believe that each woman should have a separate room. As the hospital should be constructed on the pavilion principle, the blocks must be small; but as the majority of lying-in cases do not require such constant watching as other cases, *one* head-nurse may supervise several small wards. One great advantage of small wards is that they can be easily closed for cleansing purposes, and each room be disused for a time in turn.

Refuges for those removed from Infected Dwellings.

These should be provided in every town where numbers reside in one house, in order to stop the spread of an epidemic which may have broken out. The sick should at once be removed to a hospital, and the healthy to a refuge where they

can be watched against the outbreak of further cases, thus enabling the infected house to be cleansed and disinfected. The refuge should be arranged in *sets* of rooms, so that each family removed to the refuge could be kept together. This is necessary not only for the comfort of the family, but also for limiting the spread of the disease to the particular group of people among whom it originated.

Quarantine.

The system of placing vessels arriving from countries where contagious zymotics prevail in quarantine has been almost abandoned in this, although still in use in many foreign countries. Instead of quarantine, the system of examining those on board ships coming from infected ports, and detaining the sick in port hospitals (already referred to), and allowing the healthy to land, has been substituted. The reasons for abandoning quarantine are, that the results obtained by this method were not commensurate with the trouble and loss inflicted on the individuals detained, and the interference with trade. The loss and inconvenience arising from quarantine were so great that there was great inducement to avoid it, and thus many diseases were introduced in a contraband way. Few, however, object to the system of inspection and removal of the sick, so that the inspection system, though less stringent in its rules and less annoying to those concerned, is likely to prove more efficient than the old quarantine system. The International Sanitary Congress, held at Vienna, July, 1874, decided that "land quarantine is impracticable, useless, and injurious to the interests of commerce, and should not be enforced." Although there was some difference of opinion among the members of the congress as to whether quarantine should be enforced in its full sense, yet the congress ultimately arrived at the conclusion that the inspection system,[1] accompanied by efficient disinfection, might be substituted for it.

[1] *London Medical Record.* August, 1874.

CHAPTER XXV.

Meteorology and Climate.

Modern Meteorology—Buys Ballot's Law—Meaning of Terms "Cyclonic" and "Anticyclonic"—Continuous Registration of Weather Phenomena—Weather Telegraphy. Climate, Defined—Conditions on which its Characters Depend—Winter and Summer Climates of the Northern Hemisphere—Winter and Summer Climates of the British Islands. Local Climates—Depend on (1.) *Configuration of Surface;* (2.) *Vegetation;* (3.) *Soil;* (4.) *Presence of Water.* Diseases connected with Presence of Water in the Soil.

Meteorology, in by-gone days, was limited in its application to appearances in the sky, whether atmospherical or astronomical in their character; and this was in strict accordance with the etymology of the word.[1] At the present day, however, the word is used in a much more extended sense, to denote a branch of natural philosophy which deals with weather and climate; its astronomical connexions are, to a great degree, severed, while many terrestrial phenomena are included within its vast domain, and are studied and explained under some of its many branches.

So recently as twenty years ago very little was known as to the dependence of the direction and force of the wind on barometrical and thermometrical conditions—at least outside the tropics. But in 1854, the Rev. Dr. Lloyd, the present distinguished Provost of Trinity College, Dublin, demonstrated the cyclonic character of most of the gales experienced in Ireland,[2] and so foreshadowed what is now universally

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[1] Τὰ μετέωρα = "Things in the air," "natural phenomena," "the heavenly bodies"—Cicero's "Supera atque cœlestia."—(*Liddell and Scott.*)

[2] Notes on the Meteorology of Ireland. *Royal Irish Academy Transactions.* Vol. xxii. Science. 1854.

known as *Buys Ballot's Law*—a law on which the whole of modern meteorology turns. As applicable to the Northern Hemisphere, it may be concisely stated as follows:—

"If at the same moment of time there be a difference between the barometrical readings at any two stations within a reasonable distance from each other, a wind will blow on that day in the neighbourhood of the line joining those stations, which will be inclined to that line at an angle of nearly 90°, and will have the station where the reading is lowest on its left-hand side."

In more homely language—"If on any day a person stands with his back to the wind, the reading of the barometer will be lower at all stations on his left-hand than it is where he is at the time."

Thus the *direction* of the wind is determined by differences in atmospherical pressure which are marked by differences in the height of the barometer. But further, the *force* of the wind is chiefly regulated by the amount of those differences, or by what are called the "barometrical gradients." "The gradients adopted by the Meteorological Office, London, are expressed in hundredths of an inch of mercury per 50 geographical miles."[1]

In a paper on "Weather Telegraphy," by Mr. R. H. Scott, the present Director of the Meteorological Office, the following passage occurs:—

"The immediate result of the law is to show that whenever barometrical readings are lower over any area than over those adjacent to it, the air will sweep round that area as a centre, and the direction of its motion will be opposite to that of the hands of a watch. Conversely the air will sweep round an area of relatively high barometrical readings in the direction in which the hands of a watch move. The former of these motions is said to be *cyclonic*, the latter *anticyclonic*. These names are derived from the word 'cyclone,' the general name for hurricanes and typhoons, in all which storms the motion of the air takes place around an area of diminished barometrical pressure. . . . The actual movement of the air has no reference, either in direction or velocity, to

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[1] *Barometer Manual*, Board of Trade. 1871. Page 21.

the absolute readings of the barometer at the point where it is lowest, or to the distance of the particles of air which are in motion from that point, but it is related almost entirely to the distribution of pressure in accordance with *Buys Ballot's Law.* The law gives the direction of motion, and its truth for these islands and the adjacent parts of the earth's surface is incontestable."

The study of modern meteorology is now conducted on two systems in the United Kingdom. The first is the *continuous* registration of weather phenomena at self-recording observatories. Of these there are at present seven—three in England, at Kew, Stoneyhurst, and Falmouth ; two in Scotland, at Aberdeen and Glasgow ; and two in Ireland, at Armagh and Valencia. At these observatories self-recording instruments are in action at all times—barometrical, thermometrical, and hygrometrical observations being taken by means of photography, while the direction and force of the wind and the rain-fall are registered by machinery connected with clock-work. The second system consists in the application of telegraphy to meteorology. Observations are taken at 8 A.M. daily over an extensive area, and telegrams containing the results are forwarded immediately to the Meteorological Office in London, also to similar offices in the capitals of different countries. The London Office receives telegrams at present from stations in the Baltic, Sweden, Norway, Denmark, Germany, Holland, Belgium, France, Spain, the Shetland Isles, Hebrides, Scotland, Ireland, England, and Wales. These telegrams reach the office generally about 11 A.M. The observations are then reduced and discussed, and from them a daily weather report is drawn up, lithographed, and sent out early in the afternoon to many of the London papers. Daily weather charts are also published on the same sheet, and on them are drawn the isobars, or lines of equal barometrical pressure ; the isotherms, or lines of equal temperature ; curves illustrating the general direction of the wind ; notes of the prevailing weather, rain, storm, etc., at 8 A.M., over most of Western Europe.

CLIMATE (Gk. κλίμα = *slope*, *inclination*) may be briefly defined as the meteorological conditions of a place or country, studied in relation to their effects on the animal and vegetable kingdoms. It depends principally on (1.) distance from the equator; (2.) physical configuration of surface; (3.) elevation; (4.) nearness, or otherwise, of oceans, etc.

In our study of climate we may lay down as aphorisms—

First. That hot air is lighter than cold air.

Secondly. That the rapidity with which the processes of

heating and cooling of air goes on is in direct proportion to the amount of aqueous vapour contained in that air—dry air becoming heated or cooled more rapidly and more completely than moist air, other conditions being alike.

Thirdly. That, consequently, the air over large areas of land, being drier, becomes more rapidly heated in summer and more rapidly cooled in winter than air which is in contact with extensive water-surfaces; and,

Fourthly. That the radiation-heating power of dry land is greater than that of water, as also the radiation-cooling power of dry land is greater than that of water.

This group of facts is of paramount importance in climatology.

Now let us apply these facts. Over the centre of the great continents of Europe and Asia the air in summer becomes much warmer than that over the Atlantic Ocean to the west, and over the Pacific Ocean to the east; the barometer consequently falls over Russia, Siberia, and other inland countries, the isobars,[1] or lines of equal barometrical pressure, curving round the point of lowest pressure, while it remains tolerably high over the oceans mentioned. In accordance with *Buys Ballot's Law*, a circulation of air will commence round the barometrical depression thus formed—a vast *cyclone* becomes developed, the winds blowing against the hands of a watch, from S.W. in India and China (the S.W. monsoon); from S., S.E., and E. in Japan, and North-eastern Siberia; from N.E. and N. in North-western Siberia; from N.W. and W. over most of Southern Europe and South-western Asia.

In winter, on the contrary, the air over the central districts of Europe and Asia, rendered dry by the intense heat of summer, and its accompanying excess of evaporation, becomes rapidly chilled to an extreme degree; the air is condensed, and the barometer rises while pressure coincidently diminishes over the Atlantic and Pacific Oceans, where the temperature

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[1] Gk. *ἴσος* = *equal*, and *βάρος* = *weight*.

is perhaps 60° or 80° higher. Owing to the decreasing temperature, also, the air over these oceans becomes saturated with moisture, frequent rains result, and a further reduction of pressure, consequent on the latent heat set free in the formation of rain, occurs. Thus, conditions just the reverse of those observed in summer will be established—an immense anticyclone is formed, the winds circulating round and *out from* the centre of high pressure in a direction with the hands of a watch, blowing from N.W. and N. in Japan and China; from N.E. in India (the N.E. monsoon); from E. and S.E. in Russia and Southern Europe; from S.W. in the British Isles; and from W. in Northern Russia and Siberia.

We can, indeed, form but little idea of the enormous changes of temperature which take place in Central and Northern Asia between the seasons of summer and winter. But that these changes are sufficient to produce the great variation in barometrical pressure on which depends the varying wind-system of the continents of Europe and Asia in those seasons may be easily shown by a comparison of the range of temperature between July and January in an insular[1] climate like our own, and at Yakutsk in Siberia, which is situated close to the centre of lowest and highest barometrical pressures in those months respectively. At Dublin the mean temperature of July is about 60° F., of January about 40° F.—a range of only 20°. The corresponding mean temperatures at Yakutsk are 74° F. and −40° F. respectively—a range of 114°. For weeks in summer the thermometer ranges between 80° and 90° at this place, while in winter it may descend 90° below the freezing point of water. Well does Humboldt observe:[2]—

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[1] The term *Insular* and *Continental*, as applied to climate, usually signify merely that it is characterised by a small or by an extreme range of temperature respectively, without any reference to the geographical position of a place as regards the seaboard.

[2] *Kosmos*. Vol. i. P. 352.

"The inhabitants of the countries where such *continental climates* prevail seemed doomed, like the unfortunates in Dante's *Purgatory*—

"'A soffrir tormenti caldi e geli.'"

Or, as Milton has so admirably expressed it—

"From beds of raging fire to starve in ice."

In the winter season the predominant winds over Scandinavia are south-easterly, but this apparent anomaly is in fact a beautiful fulfilment of the very laws it seems to contradict. We have seen that in winter a barometrical depression exists over the North Atlantic Ocean. It is this which draws the wind from S.E. over Sweden and Norway, in strict agreement with *Buys Ballot's Law*.

The foregoing considerations facilitate an explanation of the climate of the British Isles (1.) in summer and (2.) in winter.

It will easily be seen how the summer continental depression influences the climate of the British Isles. Air is drawn from W. and N.W. over these countries, and as this air blows over the surface of a wide ocean, and from high latitudes, it is cool and moist. Do not these two words describe our summer? These ocean winds prevail chiefly on the W. and N.W. shores of Ireland and Scotland, which have thus the rainiest and the coolest summer, while this season is warmer and drier as we go eastward and southward, to the south-eastern counties of England. This is well illustrated in Mr. Buchan's Chart[1] of the Isothermals[2] of the British Isles in July.

It is not necessary to consider at length the influence of the winter-system of barometrical pressure on our climate. During the earlier winter months a great stream of warm, very moist air, as a rule, flows north-eastward and northward over these islands round the Atlantic depression, the centre of which lies near Iceland. But this stream does not flow evenly. Along its eastern edge it is in continual conflict with the cold anticyclonic air, which is travelling westward from Russia and Siberia, and immense volumes of the latter are frequently rushing in to supply the place of those volumes of the warm air which, owing to their low density, have presumably risen from the earth's surface towards the

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[1] "The Temperature of the British Islands." By Alexander Buchan: *Journal of the Scottish Meteorological Society*, October, 1870.

[2] Gk. *ἴσος* = *equal*, and *θέρμη* = *warmth*.

higher strata of the atmosphere. This conflict between two such opposite currents of air causes our storms, and those violent and rapid alternations of temperature which are so prejudicial to health in the winter months.

The reason for the occurrence of these alternations of temperature will be explained when we remember that most of these gales, or *bourrasques* as they have been termed, are cyclonic in character, and that they generally cross the British Isles from S.W. to N.E., less frequently from W. to E., and still less frequently from N.W. to S.E. The southerly winds which blow over the country in front of the centre of the storms are warm and moist, while the northerly winds, which prevail over those districts already reached and passed by the centre, are cold, and after a time dry. No better examples of this can be given than the remarkable gales of December 8th and 9th, 1872, and of February 2nd, 1873. In front of the former temperature rose generally to about 50° over the south of Ireland, most part of England, and all of France ; while it fell almost to the freezing point over those districts a few hours later when the centre had passed. The second gale referred to was accompanied by a range of 18° (Fahrenheit) over the whole of France.

The effect of the warm Atlantic air-current on the Isothermals of the British Isles is well represented in Mr. Buchan's Chart for January.[1]

Anticyclonic wind-systems sometimes prevail over western Europe, but much less frequently than cyclonic systems. They cause dry, often cold weather, and are much more persistent than cyclones.

So far we have been engaged in discussing the topic of climate generally, and the laws by which it is regulated. We shall now briefly consider the equally important subject of local climate. The principal conditions which influence it and determine its character are—(1.) *Configuration of the surface of the ground;* (2.) *Vegetation;* (3.) *Soil;* and (4.) *Presence of water.*

(1.) *Configuration of Surface.*—As a rule, when the surface slopes away from the sun, the rigour of the climate is intensified. We have especially striking examples of this in North Germany, Siberia, and those parts of North America which slope towards Hudson's Bay. The converse is also true, and is exemplified in the excessive summer-heat of Northern Italy, India, and Southern China. Most winter resorts are situated on grounds having a southern, or solar, aspect. But leaving out of consideration the *direct* influence of the presence or absence of the sun's rays, the cooling of the air by terrestrial radiation is found to effect

[1] *Loc. cit.*

localities in very different degrees. Where the surface is uniformly level, as in the case of plains or table-lands, radiation proceeds uniformly, and the whole district is equally chilled. If the air is calm, and the sky clear, radiation goes on rapidly, and the temperature falls. Should the sky be clouded and the air in motion, radiation is uniformly checked. The alternations in either case are similar over the whole area of level ground. In hilly or mountainous districts radiation acts as before, but the air which is cooled becomes specifically heavier, and immediately commences to flow down the mountain sides. As it is replaced by warmer air, the temperature remains comparatively high and uniform. On high ground, also, the atmosphere is seldom calm, so that radiation is usually more or less checked, and warmth is maintained. Valleys, however, experience extreme variations of temperature for two reasons—first, because the cooled air flows down into them from the surrounding high grounds ; and, secondly, because, being so much shut in, they are fully exposed in the absence of wind to the influence of radiation. Illustrations of these facts will occur to every reader.

(2.) *Vegetation.*—A district covered with a luxuriant growth of plants and forest trees has a comparatively uniform and temperate climate. By day the heat is lessened, because the vegetation intercepts a large proportion of the sun's rays, which would otherwise heat the earth's surface ; also, because the evaporation from leaves and grasses renders heat latent, and so keeps the atmosphere cool. By night radiation from the surface of the ground is checked, and so the fall of temperature is diminished. Forests control evaporation, and increase the humidity of the air ; they also increase the rainfall. As moist air prevents excessive heat in summer and excessive cold in winter, forests are thus seen to be of use in mitigating extremes of climate. In winter they afford shelter from storms, and in tropical climates the spread of malaria is prevented by the interposition of trees.

(3.) *Soil.*—With regard to the absorbing power of heat possessed by soils, Schübler has arranged them in the following order,[1] 100 being assumed as the standard :—

Sand with some lime, 100 ; pure sand, 95·6 ; light clay, 76·9 ; Gypsum, 73·2 ; heavy clay, 71·11 ; clayey earth, 68·4 ; pure clay, 66·7 ; fine chalk, 61·8 ; humus,[2] 49. This list shows the high absorbing power of

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[1] Parkes' *Manual of Hygiene.* 4th edition. P. 312.

[2] Humus is the organic matter of the soil, which is made up of the products of the decomposition of vegetable substances. These products may be arranged in three classes—(1.) those soluble in water—crenic, apocrenic, and ulmic acids ; (2.) those soluble in alkaline solutions, but not in pure water—humic and geic acids ; (3.) those insoluble—humin and ulmin.

the sands, and the comparative coldness of the clays and humus. The absorbing power of water possessed by soils varies in a similar manner—sands retain but little water, clays about 10 to 20 times as much as sands, and humus double as much again. Clays and humus are comparatively unsuitable as sites for building, owing to their characters of coldness and dampness. In some diseases they are very injurious, as, for example, in phthisis, rheumatism, and catarrh. If damp soils be exposed to a high temperature, they may give rise to malaria, owing to decomposition of the organic matter mixed with them. Marshy soils, alluvial soils, old estuaries, and deltas, contain much organic matter, and should be regarded with suspicion. Peaty soils also are largely composed of organic matter, but they are not malarious, owing probably to the preservative properties of peat. Granite, metamorphic and trap rocks, clay-slate, chalk, sandstone, gravels, and the pure sands, are healthy, and suited for building sites. The limestone and magnesian limestone rocks and mixed sands are only moderately healthy.[1]

(4.) *Presence of Water.*—Perhaps no single element has a greater influence upon climate than the presence of water. Its specific heat[2] is only *one-fourth* that of dry land, and consequently it absorbs heat more slowly, stores up a larger amount of it, and parts with it less rapidly. Again, owing to condensation by cold, surface water, when exposed to low temperatures, sinks, and its place is taken by the deeper strata of warmer liquid. Equilibrium of temperature is thus maintained in the neighbourhood of extensive areas of water. In warm weather evaporation from water surfaces tends to cool the superincumbent air, to increase the humidity, and to fill the atmosphere with clouds. Hence the equable, cloudy, and moist climates of seaboards. These effects are intensified in the case of oceans, such as the Pacific and Atlantic, in winter time, by the setting towards the Arctic and Antarctic regions of immense surface-currents of warm water. The best known of these currents is the Gulf Stream, which flows north-eastward along the western coasts of Europe, and to which we are so largely indebted for our wonderfully mild winters. Extensive lakes produce similar effects on a smaller scale. Thus, in the Canadian winter, what may be a storm of rain on the shores of Lake Superior is often a fall of snow a few miles inland. When districts of country are partly covered with water, the climate is rendered damp and cool, for the evaporation from wet earth is much greater than that from an uniform water-surface. Under such

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[1] *Cf.* Parkes—*Loc. cit.* P. 314, *seq.*

[2] The *specific heat* of a substance is the number of units of heat required to raise the temperature of one pound of it by one degree.

circumstances there is reason to believe that a climate would even be improved by changing marshes or morasses into sheets of open water. Like good results often follow the carrying out of effective drainage works, and there can be no doubt that, if the water-shed of the Shannon, for example, were properly drained, the climate of the whole of Ireland would be made drier and warmer. This is a subject of vital importance to all who have agricultural interests in view, as well as to those who have regard to the public health. Three diseases, leaving ague out of the question, appear to be intimately connected with the presence of water in the soil. In 1862, Dr. Bowditch, of Boston, U.S., drew attention to the relations between the prevalence of phthisis and the amount of sub-soil water. His researches were amply confirmed by Dr. Buchanan,[1] who discovered that the death-rate from phthisis in various towns in England was greatly reduced in consequence of efficient drainage and removal of the sub-soil water. The chief facts bearing upon this point have been given in the Table on page 117. Some years ago Pettenkofer advanced the doctrine of the ultimate dependence of enteric fever and of cholera on the varying level of the sub-soil or "underground" water,[2] the most dangerous period, according to him, being that of the sinking of the water after a previous rise.

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[1] *Ninth and Tenth Reports of the Medical Officer of Health to the Privy Council.*

[2] *Zeitschrift für Biologie*, 1868.

CHAPTER XXVI.

Meteorological Observations.

Meteorological Conditions in relation to Health.—*Temperature*—Extreme temperatures—Solar radiation—Terrestrial radiation—Mean temperature.—Graduation of Thermometers.—Scales of Fahrenheit, Réaumur, and Celsius. *Humidity*—Relative humidity.—Absolute humidity.—Dew-point.—Tension of aqueous vapour.—Determination of dew-point and of relative humidity. *Rainfall*—Rain gauge.—Its position.—Mode and time of reading rainfall. *Pressure of the Atmosphere.*—Mercurial barometer alone suitable for use.—Correction for altitude and for temperature. *Wind.*—Its direction and force.—Beaufort and other scales. *State of the Sky.*—Amount of cloud.—Direction *from* which cloud Strata are moving.—Forms of clouds. *Weather.*—Beaufort scale. Meteorological phenomena connected with the sky and the animal and vegetable kingdoms.

The meteorological conditions which possess the greatest interest and value for Medical Officers of Health, from their influence on disease and death, are, undoubtedly, *temperature*, *humidity*, and *rainfall.* But as these depend, to a large extent, on the state of the barometer, the direction and force of the wind, and the condition of the sky as regards cloud, fog, and mist, it is necessary to study the latter group of phenomena also.

It would be impossible in this place to give a detailed description of the various instruments required by the observer. A full account of them may be found in any standard work on meteorology; and it will be sufficient to state here that none but really good instruments should be employed, otherwise the observations which are taken lose all their scientific value, and become practically useless.

The meteorological elements which it will be especially advantageous for the Medical Officer to observe, namely, *temperature*, *humidity*, and *rainfall*, must now be spoken of more particularly.

TEMPERATURE.—Under this heading we include extremes of temperature. Extreme temperatures are further subdivided into those observed in the shade, and those observed under the full influence of radiation. The shade thermometers in common use include a maximum and a minimum. They should be suspended at a height of four feet from the ground, in a louvre-work stand, placed with a northern aspect. They will then be well sheltered from rain or from the sun's rays. The bulb of the maximum shade thermometer should be at a slightly higher level than the opposite end of the stem, while the minimum thermometer should, on the contrary, be inclined towards the bulb. If observations are made twice daily, say at 9 a.m. and 9 p.m., the minimum may be read at the morning observation, the maximum at that of the evening—or both may be read in the evening. In either case, the readings should be entered for the day on which the observations are made. The radiation thermometers are likewise a maximum and a minimum. The former indicates the highest temperature in the sun, and consequently the temperature of the surface when freely exposed to the direct rays of the sun (solar radiation). The instrument, a blackened-bulbed thermometer *in vacuo*, should be freely exposed to the sun in an open space, and supported a little above the ground by two small forked sticks. The bulb should face the south meridian. Its readings may be recorded once daily—either in the morning or in the evening. The minimum radiation thermometer shows the lowest temperature on the grass (terrestrial radiation). It should be placed similarly to the black-bulb instrument, and its readings may be recorded at the same time.

The results deduced from observations made with the foregoing instruments are of much value from a medical point of view, for they show the greatest variations in temperature to which a given locality is subject, and this is a far more important factor than *mean temperature*, when long periods of time are considered. For example, two places may have the same annual mean temperature of 50° ; but in the one the mean temperature of winter may be 10°, that of summer 80°, while in the

other these seasons may differ in mean temperature by only 20°. The grass radiation thermometer is also most useful, for a frost, very injurious to health, often happens when the air or shade instruments indicate a temperature perhaps so much as 10° above the freezing point. This is of especially frequent occurrence in the late spring months, when the skies are clear and the air still and dry. Daily *mean temperatures* are calculated from observations made with the maximum and minimum shade thermometers. If the observations are taken hourly, then we obtain almost the absolute mean temperature of a day by dividing the sum of twenty-four observations by 24. The mean temperature may also be approximately arrived at from *one* observation in the 24 hours of both the instruments mentioned. The sum of the observations divided by 2, however, does not give a very accurate result. Various formulæ have been proposed to ensure accuracy. The simplest of these is that given by Kaemtz, and modified by the Rev. Dr. Lloyd, Provost of Trinity College, Dublin.

$$\text{Min.} + \left\{ (\text{Max.} - \text{Min.}) \times \text{coefficient } a \right\} = \text{M. T.}$$

Coefficient a has been reduced from a comparison of the Two-Hourly Observations of the thermometer, taken in 1841, 1842, and 1843, in the Observatory of Trinity College, with the readings of a self-registering thermometer for the same period. The value of the coefficient varies at different periods of the year, from ·357 in October and November, to ·407 in December and the four following months, and to ·473 in the summer months. For all practical purposes, it will suffice to use its mean annual value, namely, ·41. Our formula then reads:—

$$\text{Min.} + \left\{ (\text{Max.} - \text{Min.}) \times \cdot 41 \right\} = \text{M. T.}$$

For example:—

Max. temp. observed on October 20, 1874, = 54·2°.
Min. temp. „ „ „ = 41·4°.

Then—

$$41{\cdot}4^\circ + (12{\cdot}8^\circ \times {\cdot}41 =)\ 5{\cdot}25^\circ = 46{\cdot}65^\circ = \text{M. T.}$$

Monthly mean temperatures are obtained by adding together the daily mean temperatures for a month and dividing the sum by the number of days in the month ; or by treating the maximum or minimum observations for the month in the same way, and then applying the formula given above. Yearly mean temperatures are similarly obtained, *mutatis mutandis.*

As our readers are aware, thermometers are graduated according to three scales—those of Fahrenheit, Réaumur, and Celsius. According to the first, the melting point of ice is 32°, and the boiling point of water 212°. Between the two points, therefore, there are 180°. In both the other scales

the melting point of ice is 0°, or zero. In the Réaumur scale the boiling point of water is 80°, in that of Celsius it is 100°. Hence the latter scale is of tencalled the *Centigrade* scale. We see, then, that 180° on Fahrenheit's scale corresponds with 80° on that of Réaumur, and 100° on that of Celsius. The reduction of readings on one scale to those on another is a very simple matter. We have the following proportions for Fahrenheit's thermometer:—

F : R : : 180 : 80, *i.e.*, 9 : 4. Therefore, $F = \frac{9R}{4} + 32°$.

F : C : : 180 : 100, *i.e.*, 9 : 5. Therefore, $F = \frac{9C}{5} + 32°$.

Before passing from the subject, it is necessary to observe that every thermometer should have the scale *engraved on the glass stem*, and should be verified at Kew, or some other recognised official observatory.

Humidity.—For the determination of the humidity of the atmosphere various instruments are employed. But those most commonly used are two thermometers—one called the "dry-bulb," the other the "wet bulb." The dry-bulb is generally a simple non-registering mercurial thermometer. The wet-bulb differs from it only in having its bulb covered with a piece of very fine muslin, and connected by means of an ordinary spirit-lamp wick with a vessel of distilled water. The water is drawn up the wick by capillary attraction, and is evaporated from the surface of the muslin. As heat is made latent when water assumes the form of vapour, the wet bulb marks a lower temperature than the dry-bulb, the difference being greater in proportion to the rapidity of evaporation. The temperature indicated by the wet-bulb is sometimes called the "temperature of Evaporation." In frosty weather, it is sometimes necessary, just before an observation is taken, to moisten the wet-bulb with water of a temperature as near that of the air as possible. Otherwise the instrument may strike work, owing to the freezing of the

water in the muslin and wick, and the complete evaporation of the resulting ice.

By the term "relative humidity" is denoted the percentage amount of moisture, or aqueous vapour in the atmosphere, complete saturation being represented as 100. The "absolute humidity" is the actual amount of moisture, or aqueous vapour, in a given quantity of air. The "dew-point" is the temperature at which the air becomes saturated with the moisture it contains. Any further chilling below this temperature would be attended by an immediate condensation and precipitation of water in the form of dew, hoar-frost, mist or snow. The "tension of aqueous vapour" is the expression, in inches of mercury, of the elastic force exerted in the atmosphere by the aqueous vapour contained in it. The pressure of the atmosphere as indicated by the barometer is made up of this elastic force of vapour at the existing dew-point temperature, and of the weight of the *dry* air above the surface of the mercury in the cistern of the barometer. The medical man is interested much more in the determination of the relative humidity than in that of the absolute humidity.

The former may be obtained by dividing the tension of aqueous vapour at the temperature of the dew-point by that at the temperature of the air, at any moment of time. Tables containing the tensions, at every degree of Fahrenheit's scale, have been published by Mr. Glaisher. (See Appendix III., Table 1.)

Mr. Glaisher has also compiled a Table of Factors, for use in the determination of the dew-point. These factors will be found in Appendix III., Table 2.

The dew-point can be directly determined by an experiment with Regnault's hygrometer. In 1834 and 1835, Dr. Apjohn, the distinguished Professor of Chemistry in the University of Dublin, read before the Royal Irish Academy a paper on the moist-bulb hygrometer. He proposed the following formula for the determination of tension of aqueous vapour at the dew-point temperature :[1]—

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[1] We quote from a capital work on *Practical Meteorology*, by Dr. John Drew., F.R.A.S. Second Edition. 1860. Pp. 146 and 147.

"Let f = tension of aqueous vapour at the dew-point temperature which we desire to know.

f' = the tension of vapour at the temperature of evaporation, as shown by the wet-bulb thermometer.

a = the specific heat of air.

e = the latent heat of aqueous vapour.

$(t-t')$ or d = the difference between the reading of the dry-bulb thermometer and that of the wet.

p = the pressure of the air in inches: then Apjohn's formula is

$$f=f'-\frac{48a(t-t')}{e}\times\frac{p-f'}{30};$$

or with the coefficient,

$$f=f'-{\cdot}01147\ (t-t')\times\frac{p-f'}{30}.$$

"The following is the formula (derived from Apjohn's), as given in the Greenwich observations, which will be made use of in this work; h being the height of the barometer.

$$f=f'-\frac{d}{88}\times\frac{h}{30}.$$

"When the reading of the wet-bulb thermometer is below 32°, the formula becomes

$$f=f'-\frac{d}{96}\times\frac{h}{30}."$$

As we have just said, the dew-point may also be calculated from the reading of the dry and wet bulb thermometers, by means of Glaisher's factors, in the following manner:—From the dry-bulb reading subtract the wet-bulb reading, multiply the difference by the factor corresponding to the dry-bulb reading, and subtract the product from the dry-bulb reading. The result is the dew-point.

For example:—

Dry-bulb = 53°.

Wet-bulb = 49°. Then,

53° − 49° = 4° × 2·00 (the factor corresponding to 53°) = 8.

53° − 8° = 45° = the dew-point temperature.

Rainfall.—The simplest form of rain-gauge is a round funnel of 5, 6, 8, or 12 inches diameter, with a projecting perpendicular rim, surrounding its edge, and leading into a receiver of glass or metal. From the receiver the water is poured into a graduated measuring glass. In order to secure accuracy, a rain-gauge must be well exposed, at a considerable distance from buildings, trees, walls, or anything which

might intercept the rain. The more level the ground is the better. The brim of the receiver should stand 3 feet, or, at all events, 1 foot from the ground, so as to avoid the influence of splashing.

The rainfall should be read at 9 A.M. daily, and the amount—expressed in inches and decimals of an inch—should be entered to the day preceding that of observation. This rule has been adopted by meteorologists almost without exception. Snow or hail should be gradually melted, and the resulting water measured as rain. If the snow has fallen dry, with a high wind, a great part of it may drift out of the receiver. Then it becomes necessary to measure the depth of the snow on a sheltered piece of ground. *One-twelfth* of the depth will give, approximately, the yield of water, *e.g.*, 3 inches of snow = ·25 in. of rain.

It will be very desirable to have observations taken, in addition to those on temperature, moisture, and rainfall, on the state of the barometer, wind, and weather. A few hints, therefore, are here given as to the best way of effecting this object.

PRESSURE OF THE ATMOSPHERE.—The scientific use of the barometer and the connexion between the distribution of atmospherical pressure, as shown by it, and the direction and force of the wind, have been pointed out in the preceding chapter. Mercurial barometers are alone suited for accurate observations; for no matter how carefully constructed aneroid instruments may be, they are liable to go out of order, unless they are compared from time to time with mercurial standard barometers. Whenever such a comparison is made, the reading of the mercurial barometer should be reduced to 32°. Probably the most serviceable instrument is the marine barometer, proposed some years ago by Mr. Adie, and adopted by the Government. It is, in all respects, a first-rate instrument, and is equally available for land or sea service. By means of the vernier, the height of the mercurial column can be read off to one-thousandth of an inch.

To secure uniformity in observations from different places, it becomes

necessary (in addition to the application of the instrumental corrections incidental to every barometer) to reduce the observed readings to 32° F. at the Mean Sea Level at Liverpool—the Ordnance Survey Datum. The height of the cistern of the instrument should, therefore, be correctly ascertained by levelling from the nearest Ordnance Survey Bench-mark, or otherwise. In all cases, the correction for *altitude* is to be added to the observed reading. A Table (3.) of such corrections will be found in Appendix III.

Reduction to 32° is effected by the use of a Table giving the necessary corrections for every degree of Fahrenheit's thermometer at different heights of the barometer. In this case when the temperature is below 29°, the correction has always a *plus* value, *i.e.*, is to be added to the observed reading. Above 29° the corrections are always *minus*, and should be subtracted from the reading. (See Appendix III., Table 4.)

WIND.—The *direction* of the wind should be *true*, and not magnetic—that is, ascertained by compass. If it is so ascertained, the variation of the compass at the place of observation should be noted, and the necessary correction applied. In the absence of a vane, smoke from a chimney, *freely exposed*, gives an admirable idea of the direction of the wind. The observer should watch the smoke for some time, to make sure that the eddies in the air do not spoil his observation. The direction of the upper and lower strata of the clouds may be noted with advantage at the same time. Sometimes so many as three or four different currents of air are blowing over the same place. As regards the *force* of the wind, probably the most accurate results are obtained from Dr. Robinson's small-size anemometer (price four guineas). Where no instrument of this kind is available, a practised observer is easily able to estimate the force of the wind by the "Beaufort Scale," which is employed by all the observers for the Meteorological Office, London. According to it, a calm is valued as 0, a hurricane as 12. Another scale, that of 0 to 6, gives values which may be converted into pressure in pounds on the square foot by simple squaring. It is necessary to observe, however, that the question of equivalents of wind-force is still quite unsettled.

Table of Equivalent Scales of Wind-Force.

Scale 0 to 6	Pressure in pounds per sq. foot	Approximate Velocity in miles per hour	Beaufort Scale	
0·0	0·00	3	0	Calm
0·5	0·25	8	1	Light air
1·0	1·00	13	2	Light breeze
1·5	2·25	18	3	Gentle breeze
2·0	4·00	23	4	Moderate breeze
2·5	6·25	28	5	Fresh breeze
3·0	9·00	34	6	Strong breeze
3·5	12·25	40	7	Moderate gale
4·0	16·00	48	8	Fresh gale
4·5	20·25	56	9	Strong gale
5·0	25·00	65	10	Whole gale
5·5	30·25	75	11	Storm
6·0	36·00	90	12	Hurricane

State of the Sky.—A note should always be taken as to the *amount of cloud* at the time of observation. The proportion of sky obscured by all kinds of clouds is to be entered according to the scale 0 to 10—0 indicating a cloudless, and 10 a completely overcast sky. When the observer's eye scans that portion of the heavens near the horizon, allowance should be made in the estimation for the influence of perspective. In foggy or misty weather, the proportion of sky obscured by fog or mist and by cloud, should be noted—the entire obscuration being entered as due to cloud. The *direction* of cloud strata should always be taken, and entered similarly to the direction of the wind. Thus, the direction (always *true*) is that *from* which the clouds are moving. The *forms* of clouds prevailing at the time of observation should be noted according to Luke Howard's nomenclature—the names being abbreviated thus:—Cirrus=*cir.*; Cirro-cumulus=*cir-c.*; Cirro-stratus=*cir-s.*; Stratus=*str.*; Cumulus=*cum.*; Cumulo-stratus=*cum-s.*; Nimbus=*nim.* Should more than one stratum be presented, an entry such as $\frac{\textit{cir.}}{\textit{cum-s.}}$ can

be made, when *cir.* will be the form of the upper and *cum-s.* that of the lower stratum.

WEATHER.—The chief character of the prevailing weather should be noted in letters, according to the Beaufort Scale, viz.:—

b = blue sky.
c = detached clouds.
d = drizzling rain.
f = fog.
g = gloomy.
h = hail.
l = lightning.
m = mist (haze).
o = overcast.
p = passing showers.
q = squally.
r = rain.
s = snow.
t = thunder.
u = "ugly," threatening appearance.
v = unusual visibility of distant objects (visibility).
w = wet (dew).

In this scale a bar (—) under a letter indicates continuity and a dot (.) intensity. The form for observations should further contain a column for additional *Remarks*, as to the prevalence of rain, hail, snow, fog, ozone, thunder, lightning, auroras, meteors, halos, rainbows, etc.; the occurrence of sudden changes of weather; the time of the commencement and ending of storms, and of veering of the wind, and so on. Notes as to the budding, leafing, and flowering of plants, the ripening of cereals, arrival and departure of migratory birds, are also useful and instructive. Above all, the Medical Officer should seek to compare the rise and fall of disease and death with the march and character of the seasons.

CHAPTER XXVII.

Influence of Season on Zymotic Diseases.

Cholera.—Generally epidemic in Autumn.—Outbreak of 1866 in Dublin.—Small-pox.—A disease of Winter and Spring.—Epidemic of 1870–71 in London.—Epidemic of 1871–72 in Dublin.—Measles.—Prevails chiefly in Spring and Summer.—Conditions of temperature which favour or check its spread.—Whooping-cough.—Prevails most in Winter, owing to the frequency of chest complications.—Conditions of temperature.—Scarlatina.—A disease of Autumn.—Conditions of temperature.—Mortality maintained in Winter by Overcrowding and defective Ventilation.—Fever.—Its two principal forms as influenced by Season.—Typhus, a disease of Winter.—Typhoid, or Enteric, most prevalent in Autumn.

In a former chapter (*Statistics of Deaths*, p. 109) allusion was made to the influence of season upon the rate of mortality in general, or the death-rate from all causes. It was there explained that the tendency to death is by affections of the respiratory organs in winter, and by abdominal diseases, such as diarrhœa and dysentery, etc., in summer. We shall now investigate the bearing of season on the principal zymotic diseases, exclusive of diarrhœa and dysentery, namely:—(1.) Cholera; (2.) Small-pox; (3.) Measles; (4.) Whooping-cough; (5.) Scarlatina; and (6.) Fever.

I. *Cholera*—That cholera tends to prevail in the warmer months of the year is sufficiently borne out by the history of the disease. In the accompanying Table are given the deaths from the disease by months in some of the great epidemics of late years, and the figures speak for themselves. In one case, that of Limerick, 1849, we meet with an early spring epidemic, and in January of the same year a large mortality from cholera prevailed in England. But these exceptions only prove the rule. If from the totals we omit the Paris outburst of April, 1832, in which city the epidemic kindled into flame for the second time in July of that year, we have an increasing series of deaths from February to September, and a decreasing series from the last-named month to December.

Table showing the Deaths from Cholera, by Months, in several Epidemics, since 1832, in various Cities and Countries of Europe.

MONTHS	England, 1832	England, 1849	Paris, 1832	Paris, 1849	Dublin, 1849	Limerick, 1849	Dublin, 1866
January, .	614	658	?	?	2	0	0
February, .	708	371	?	?	6	6	0
March, .	1,519	302	90	573	8	591	1
April, .	1,401	107	12,733	1,929	32	143	0
May, . .	748	327	812	4,509	197	4	1
June, . .	1,363	2,046	868	8,669	477	1	0
July, . .	4,816	7,570	2,573	865	314	0	2
August, .	8,875	15,872	969	1,382	276	0	74
September,	5,479	20,379	357	1,142	298	1	270
October, .	4,080	4,654	62	115	49	0	508
November,	802	844	?	?	5	0	273
December,	140	163	?	?	0	0	66

MONTHS	Sweden, 1834	Sweden, 1850	Sweden, 1866	Christiania, 1833	Christiania, 1850	Christiania, 1853	Christiania, 1866	TOTALS
January, . .	?	?	0	0	0	0	0	1,274
February, . .	?	?	0	0	0	0	0	1,091
March, . . .	?	?	0	0	0	0	0	3,084
April, . . .	?	?	0	0	0	0	0	16,345
May, . . .	?	?	0	0	0	0	0	6,358
June, . . .	?	?	4	0	0	0	0	13,628
July, . . .	30	0	483	0	0	6	0	16,659
August, . .	5,904	209	943	0	0	164	8	34,676
September, . .	6,124	213	1,209	0	0	1,356	20	36,868
October, . .	490	880	508	262	50	60	0	11,718
November, . .	58	342	30	538	37	11	0	2,940
December, . .	31	87	1	17	0	0	0	505

"Real epidemics of cholera," writes Professor Faye,[1] "in the more rigorous season of winter have very seldom occurred, while sporadic cases have very frequently shown themselves even in winter. At Breslau a winter epidemic prevailed in 1848-49, continuing from October till March, with the same fatality as had characterised summer epidemics at the same place ; and at Petersburg, as in several of the districts of Russia, cholera has prevailed in winter, although to a far less degree than in summer—so that the Russian physicians have often declared that the disease is prevalent in the winter quarter. At Bergen, in Norway, the epidemic of 1848-49 was also a winter epidemic. It is, therefore, not altogether without reason that cholera has been stated to observe no season, but if we take into consideration both the relative infrequency of its appearance in winter, and its impaired virulence under intense degrees of cold, this assertion as to the compatibility of the disease with a winter temperature experiences a very important limitation. Perhaps the explanation of the matter is not very remote. At Bergen, for example, the winter is often rainy and the air in proportion mild, so that the freezing of the earth's surface to any depth does not occur ; and the winter of 1848-49 was really of this kind. It is well known also that cholera at Petersburg in winter time is almost exclusively confined to the unhealthy houses situated on the low and swampy banks of the Neva, belonging to an indigent labouring population ; and, indeed, it is not strange that low-lying and over-crowded cellars, beneath which the soil has scarcely stiffened, with a favourable and confined oven-temperature, should foster the contagion, and occasion a constant, though tardy, propagation of the disease. Whether conditions of this kind held at Breslau I am unable to say ; but, in any case, it is certain that violent epidemics during severe winter-frost very rarely, if, indeed, ever, occur."

Professor Faye goes on to say that, while the epidemic (of 1853) was at its worst at Christiania, the atmosphere was steadily warm and the air, in addition, clear and very still. This continued for about three weeks, during which the daily numbers of cases, which were then at the highest, scarcely varied. At this point of time—the middle of September—the air was set in motion by a strong and stormy north-west wind, and, remarkably enough, the number of cases fell, *next day*, to about one-half. Similarly, at Bergen, during the epidemic of 1848–49, a strong and cold north-easterly gale, supervening on a lengthened period of milder temperature, caused a considerable fall in the number of cholera cases.

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[1] "Om Cholera-Epidemien i Norge i Aaret, 1853." ("On the Cholera-Epidemic in Norway, in the year 1853.")

In the epidemic of 1866 the acme of mortality was reached in Dublin about the middle of October, the weather of the preceding week having been continuously *calm*, *cloudy*, *foggy*, *damp*, *with a very high barometer*, *and a great deficiency of ozone* (the latter showing a mean value of only 10 per cent. at the Ordnance Survey Office, Phœnix Park).

The decrease in the mortality was consequent on a freshening and a change of wind from N.E. to S.W., a diminution of barometrical pressure, a moderate and continued rainfall, a rise in ozone to 70 per cent., and a gradually falling temperature. The coincidence of a high barometer with a great development of cholera has often been remarked, but striking exceptions are also on record. Keeping in view the fact that heavy rain and a strong breeze are most valuable detergents and disinfectants, it seems probable that the *calm weather* consequent on slight barometrical gradients, so common in anticyclonic, or high-pressure systems, has more influence than the mere height of the barometer itself. In December, the epidemic died out rapidly, and no death occurred later than the 29th of that month, on which day—it is most interesting to note—the intense frost of January, 1867, was ushered in by a fall of temperature amounting to 15° in a few hours.

II. *Small-pox.*—Small-pox is essentially a disease of winter and spring. From statistics as to the prevalence of the disease in Sweden, by months, in the years 1862–1869, inclusive,[1] it appears that its greatest prevalence is observed in May, the cases in that month being 13·7 per cent. of the total cases occurring in the year; while the least prevalence is observed in September, when only 3·9 per cent of all the cases in the year occur. From November the monthly number of cases is high, but from May a rapid decline in the prevalence of the disease takes place.

[1] These statistics were compiled from exhaustive annual reports by the late Dr. Wistrand, as to the morbility of Sweden, and are the direct fruit of an admirable system of disease-registration, which has been in operation for many years in Sweden, and also in the other Scandinavian countries.

When due allowance has been made for difference of climate, these results agree very closely with the observations which have been recorded in this country on the relation of small-pox to season. Dr. Edward Ballard,[1] writing of the recent epidemic, observed:—

"There is some reason for believing that the variations of the epidemic (of small-pox), from week to week, are influenced to a certain extent by atmospheric conditions and more especially by variation in temperature."

He then quoted a series of remarkable coincidences between the fluctuations of mean temperature and those of the small-pox mortality in London during the winter of 1870–71. In the number of the same journal for May 13th, 1871, he wrote:—

"The epidemic has now lasted a good six months. It may be regarded as assuming a distinctly epidemic form in November, shortly after the mean temperature of the air had fallen decidedly below 50°. In the progress of the seasons we have now arrived at a time when this mean temperature is again reached. The mean temperature of the last three weeks, as recorded at Greenwich, has been 50°, 50·7°, and 49·7°. It is customary about the second week in May for some check in the consecutive weekly rises of temperature to take place, but after this in the ordinary or average progress of events the steady rise towards the summer temperature may be expected to set in, and with it there is at least a hope that the epidemic will begin to fade."

A week later, the same writer said:—

"The sudden fall of deaths in London from small-pox which occurred last week, namely, from 288 to 232, occurring about three weeks after the mean temperature of 50° was reached, appears to be confirmatory of the favourable hopes we expressed last week, that the epidemic had, for this season, arrived at its climax."

And so it had, for although the decline was occasionally interrupted, the virulence of the epidemic was broken in May, in accurate fulfilment of the anticipations which had been grounded on a consideration of the influence of temperature on its progress.

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[1] *Medical Times and Gazette*, March 11, 1871.

In Dublin, during the autumn of 1871, the mortality from small-pox increased with a fall of mean temperature below 50°, and the greatest severity of the epidemic was experienced in the first half of the following April, a short time after a period of cold, which was very intense for the time of year, snow and hail having fallen in large quantities (with keen north-easterly winds) on every day from the 21st to the 27th March. The mean temperature of this period was scarcely 37°, or nearly 8° below the average. The number of deaths now began to decline, the mean temperature in two weeks (April 13th and May 4th) rising above 50°. With the rise of mean temperature to between 55° and 60° in the middle of June, the weekly number of deaths fell permanently below thirty early in July.

It is interesting to note that abundant rainfalls seemed to be followed by remissions in the severity of the epidemic; and the converse was also true, for the acme of the epidemic closely followed a period of comparatively dry weather and lower humidity.

But in connexion with the late epidemic, as regards Dublin, one of the most remarkable evidences of the dependence of the disease on climatic influences is found in the fact that, in March, 1871, a well-marked tendency to an epidemic was noticeable. Local outbreaks of the disease took place in various parts of our city, and fatal cases occurred at Cork-street Fever Hospital. By the increasing temperature, however, the disease appeared to be held in check, notwithstanding the importation from England of many cases, until, with the advancing autumn, it blazed into an epidemic.

III. *Measles.*—This disease, which, like whooping-cough, scarlatina, and fever, is always present with us, prevails especially in the spring and summer quarters of the year. An analysis of the weekly returns of deaths from measles during nine years, 1864–1872, inclusive, in Dublin (Registration District) showed that, on an average, the highest mortality fell in the twenty-eighth week of the year, and was 4·2 deaths—that from this period the average weekly number of deaths declined, with slight oscillations, to 0·6 in the fifty-first week,

remaining very low until the twelfth week, when it again permanently reached 2·0. Now, the average mean temperature of the twenty-fifth week of the year for the nine years under consideration was 58·6°. We may, therefore, conclude that a temperature higher than this is not favourable to the spread of an epidemic of measles. Similarly, the average mean temperature of the ninth week was 43·1°, while that of the forty-eighth week was 42·1°. As a low mortality from measles followed close upon the latter temperature, and lasted until the former temperature was reached in the early spring, the inference to be drawn is, that a temperature below 42° is as unfavourable to the spread of the disease as a temperature above 59°.

These results are in strict accordance with those arrived at by Dr. Ballard,[1] who says that the only condition concerned in the arrest of the spread of measles in summer is the rise of the temperature of the air above a mean of 60°, while towards winter a fall below 42° also distinctly tends to check the disease.

IV. *Whooping-cough.*—As was to be anticipated from the frequency of chest complications attending it, the disease invariably prevails most in winter, the greatest mortality generally falling in the first quarter of the year. Three epidemics of whooping-cough occurred in Dublin within the nine years, 1864–72, and all of these reached their acme in January and February. It is curious to observe that the epidemics occurred in comparatively mild seasons, namely, those of 1866, 1868, and 1871. The epidemic of 1866 also was slow in dying out, as if the cold of the second quarter of that year had kept up the mortality. It would seem, indeed, that intense cold tended to check the disease, while moderate cold favoured its prevalence. And this view is borne out by an analysis of the weekly death-rate. The average weekly deaths numbered 5·9 in the second week—allowing, then,

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[1] *Eleventh Report of the Medical Officer of the Privy Council,* 1868. No. 3. Pp. 54–62.

three weeks for (1.) the period of incubation, (2.) the length of the illness, and (3.) the delay in registration, we find the mean temperature of the fifty-first week in the nine years to have been 42°—a temperature which very remarkably corresponds with that of the three epidemic quarters, 42·2°, and which is at least 3° above the average mean temperature of the coldest week in the year.

The lowest death-rate from whooping-cough is met with in the twenty-eighth and twenty-ninth weeks, or about the middle and end of July; and, accordingly, we find the mortality to be, as a rule, lowest in the third quarter. The average mean temperature of the twenty-fifth week in the nine years was 58·6°, that of the twenty-fourth week having been 56·8°.

A rise, then, above this last temperature seems to favour the spread of the disease, although, from Dr. Ballard's observations,[1] we learn that extremely high temperatures are inimical to the epidemic character of whooping-cough.

Besides the pronounced minimum of mortality from whooping-cough just described, another minimum falls in the twenty-first week, after which a recrudescence of the disease is observed for some weeks. With this temporary rise a low humidity and a temperature of about 50° seem to be associated. Dr. Ballard especially mentions this June development of the disease as being most marked in Islington; and the Report of the Scottish Registrar-General for 1868 contains the following passages from the pen of Dr. Stark:—

"The first advent of really warm weather, during the past year, greatly increased the deaths from measles and whooping-cough; but the continuance of the warm weather rapidly diminished the mortality." "When the cold easterly winds began to blow in March, the deaths from whooping-cough in the eight towns, which numbered 87 during February, increased in March to 155; but under the influence of the spring weather, fell to 145 during April, and to 131 deaths during May. During the high temperature of June, however, the deaths from whooping-cough rose to 165, the highest they had been during any month of the year; but instead of increasing during the much warmer months of July and August, they rapidly fell, numbering 135 deaths in July, 121 in

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[1] *Loc. cit.*

August, and 92 in September—the lowest number of deaths from whooping-cough during any month of the year."

V. *Scarlatina.*—"*Scarlatina*," observes the Registrar-General of England,[1] "discovers a uniform, well-marked tendency to increase in the last six months, and attain its maximum in the December quarter, the earlier half of the following year witnessing a decrease." He illustrates this remark by a Table, which is appended, showing the deaths in London from scarlatina, by quarters, during four years:—

Deaths in London from Scarlatina.

Years.	March Quarter	June Quarter	September Quarter	December Quarter	Total
1861, . .	420	326	467	1,145	2,358
1862, . .	774	677	841	1,165	3,457
1863, . .	880	1,055	1,519	1,621	5,075
1864, . .	749	593	805	1,095	3,242
1865, . .	566	—	—	—	—

From Dr. Wistrand's *Reports on the Morbility in Sweden*, it appears that scarlatina is, as a rule, most prevalent throughout that country in November, and least so in August, results which agree tolerably closely with observations in England, except as regards the September quarter.

In Dublin, also, the disease is almost invariably most prevalent and fatal in the fourth quarter of the year. The serious epidemic which is now raging affords a striking example of this. The deaths in the first quarter of 1873 were 32; second quarter, 23; third quarter, 27; and fourth quarter (the beginning of the epidemic), 151. In the first quarter of 1874, they were 170; second quarter, 176; and third quarter, 250.

From an analysis of the weekly death-rate from scarlatina in Dublin, during nine years, it is found that the disease was, on the average, most fatal in the forty-sixth week (8·2 deaths),

[1] *Twenty-eighth Annual Report of Births, Deaths, and Marriages.* P. 38.

and least fatal in the twenty-fourth week (1·9 deaths). The average mean temperature of the forty-third week was 47·9°, that of the twenty-first week was 52·1°. It would seem, then, that scarlatina shows a tendency to increase when the mean temperature rises much above 50°, while a fall of mean temperature below this point in autumn checks the further rise of the mortality.

Dr. Ballard draws inferences which confirm these results He says:[1]—

"1. *A mean atmospheric temperature of about* 60°, *or between* 56° *and* 60°, *is that most favourable to the outbreak of scarlatina.* 2. That, for its free development, it is necessary that the humidity of the atmosphere shall not much exceed 86, or be much less than 74. 3. That a higher temperature than 60° does not appear to be in itself unfavourable to the spread of scarlatina. 4. *That a fall of mean temperature below* 53° *tends to arrest an epidemic of the disease.*"

The remark made by this author as to the influence of humidity may explain a great dip in the mortality which was observed during the hot but *dry* summer of 1868.

Dr. Tripe, Medical Officer of Health, Hackney, has investigated the influence of season on the prevalence of scarlatina in London.[2] He finds that over a long series of years, out of every 100 deaths, 17·2 were registered in Spring, 21·8 in Summer, 35·6 in Autumn, and 25·4 in Winter. According to this author, a temperature below 44·6° is adverse to the spread of scarlatina, whereas a higher temperature increases it, especially if the humidity of the air is less than usual. The greatest comparative mortality occurs in those months which have a mean temperature varying between 49·6° and 56·9° Fahr., while a mean weekly temperature below 40° Fahr. is coincident with a great decrease in the number of deaths.

But if a fall of temperature below 53° tends to arrest the disease, why is it that the mortality undoubtedly *continues*

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[1] *Loc. cit.* P. 65.

[2] *Cf. London Sanitary Record*, Nov. 14, 1874. P. 337, *seq.*

high during the colder winter months? In Dublin it continues *very high* until the ninth week, and *high* until the nineteenth week. It is well known that scarlatina is not only one of the most contagious diseases, but also that the *materies morbi* (whatever it may be) appears to be very easily diffused, and remains in an active state for a lengthened period. Hence the difficulty of disinfecting the bed-chambers of scarlatina patients.

Under these circumstances, overcrowding becomes a hundredfold more dangerous to the community. As winter approaches, the instinct is to diminish the sources of ventilation, but among the poorer classes, badly clothed, and with inadequate supplies of fuel, unrestrained freedom is given to this instinct, with most deplorable consequences. Every chink and crevice, through which the outer air might gain access to the overcrowded tenements, is eagerly sought out and effectually closed. And it is under these circumstances that scarlatina, favoured by the high and unwholesome temperature of the rooms, runs like wildfire among many families in the poorer parts of a large city. But the mischief does not end here, for the contagious powers of the disease are called into full play, and so the richer and more affluent quarters of the city suffer in their turn from this dire pestilence.

We must not forget, also, that in winter the throat complications of scarlatina are likely to be more severe and more fatal than in summer and autumn.

VI. *Fever.*—Under this term we include typhus, enteric, and the so-called simple continued fevers, as explained in Chapter XII. above. Fever appears to depend especially on the weather; but, in our consideration of the subject, it would be most desirable to isolate typhus from enteric fever. With the former we shall group simple continued fever, for it is, perhaps, more closely allied to typhus than to enteric; and we must also remember that cases of simple fever are sometimes cases merely of typhus without any eruption—non-maculated typhus, as it is termed.

Unfortunately, prior to the year 1869, no distinction between typhus and enteric fevers was made in the Registrar-General's returns of births and deaths in Dublin, but we have analysed the returns for four years, in which such a distinction was made, and the results may be looked upon as at all events approximate to the truth.

In the first place, during the nine years, 1864–1872, fever in general proved most fatal in the third and fourth weeks of the year (with 10·1 and 9·7 deaths on the average respectively), and least fatal in the twenty-eighth and twenty-ninth weeks (with 4·4 and 4·3 deaths on the average respectively), that is, the disease was most severe about the period of greatest cold, and least so early in July.

In the following Tables, in which the year has been divided into thirteen periods of four weeks each, corresponding results are brought out.

In Table XXIX. are grouped the mean number of deaths from fever, as well as those of the other endemic diseases we have been considering, into thirteen periods. From this Table, it will be seen that fever becomes very fatal in autumn, when the mean temperature falls below 54°, the mortality continues to rise with the falling temperature until January and February are past. Early in March the mortality declines, but rises again at the beginning of May, coincidently, it would seem, with a *lower humidity*. The decline is then very rapid, and the minimum is reached in the seventh and eighth periods—that is, in July and the first half of August. It is worthy of note that the sudden fall in the number of deaths in the seventh period follows the rise of mean temperature above 54° at an interval of some three or four weeks. Temperatures higher than 54° would, therefore, seem to have a controlling influence on the prevalence of fever, while temperatures below 54° seem to favour its development.

TABLE XXIX.[1]—*Showing the Mean Number of Deaths in Dublin from* (1) *Measles*, (2) *Whooping-cough*, (3) *Scarlatina, and* (4) *Fever; and the Mean Temperature, in* 13 *periods of* 4 *Weeks, during the years* 1864–72 :—

No. of Period	Mean Deaths from Measles	Mean Deaths from Whooping-cough	Mean Deaths from Scarlatina	Mean Deaths from Fever	Mean Temperature
I., . .	4·3	17·5	22·3	34·4	° 39·1
II., . .	5·1	15·4	21·4	32·8	41·7
III., . .	6·8	11·0	16·0	30·7	41·4
IV., . .	12·1	10·4	16·4	27·9	46·9
V., . .	11·0	8·3	14·5	31·6	50·8
VI., . .	12·5	7·0	12·5	29·8	54·9
VII., . .	14·4	5·4	11·1	20·9	59·5
VIII., . .	12·1	4·4	13·5	20·7	60·0
IX., . .	9·7	7·8	13·7	21·4	58·6
X., . .	8·7	6·7	18·5	21·6	54·2
XI., . .	9·7	8·2	26·7	25·7	48·7
XII., . .	5·0	11·4	26·4	31·5	43·5
XIII., . .	4·2	11·2	22·8	28·1	43·4
Average, .	8·9	9·6	18·1	27·5	49·4

[1] With respect to this and the following Table, it is necessary to explain that the fall in death-rate noticed in the thirteenth period, or last four weeks of the year, is apparently due to delay in registration at Christmas time.

Table XXX. shows the apparent influence of season on the two principal continued fevers—typhus and enteric.

TABLE XXX.—*Showing the Mean Number of Deaths from Fever in general, and from Typhus and Enteric Fever, and the Mean Temperature, in* 13 *Periods of* 4 *Weeks, during the Years* 1869–72:—

No. of Period	Mean Number of Deaths from Fever	Mean Number of Deaths from Typhus Fever	Mean Number of Deaths from Enteric Fever	Mean Temperature	Per cent. of Typhus Fever	Per cent. of Enteric Fever	Mean Fever Deaths 1864-72
I., ..	34·4	19·2	15·2	° 40·5	55·8	44·2	34·4
II., .	28·0	16·4	11·6	43·9	58·6	41·4	32·8
III., .	27·6	16·4	11·2	43·6	59·4	40·6	30·7
IV., .	27·5	17·0	10·5	47·0	61·8	38·2	27·9
V., ..	32·5	17·5	15·0	49·4	53·8	46·2	31·6
VI., .	26·3	15·3	11·0	54·3	58·2	41·8	29·8
VII., .	22·3	11·5	10·8	59·3	51·5	48·5	20·9
VIII., .	20·5	12·5	8·0	61·0	61·0	39·0	20·7
IX., .	21·7	11·0	10·7	58·2	50·7	49·3	21·4
X., .	21·0	12·5	8·5	53·9	60·0	40·0	21·6
XI., ..	27·5	14·2	13·3	48·1	51·6	48·4	25·7
XII., .	30·5	17·3	13·2	42·0	56·7	43·3	31·5
XIII., ..	23·9	11·2	12·7	39·8	46·8	53·2	28·1
Average, .	26·4	14·8	11·7	49·3	55·8	44·2	27·5

The death-rate from typhus reaches a minimum in the ninth period, while the minimal death-rate from enteric fever has already occurred in the eighth period, this fever exhibiting—as the summer rolls by—a decided tendency to increase at an earlier period than typhus. In this same Table the calculated percentages of the two diseases are also entered, and a striking increase in the percentage amount of enteric is noticed towards the close of the year. The highest percentages of typhus are met with, on the contrary, in the seasons of winter, spring, and early summer.

The reason for all this is not far to seek. Typhus is often intimately related to overcrowding, and bronchial or thoracic affections are amongst its most frequent complications. Hence we should expect to meet with it especially in the colder seasons. Enteric fever, on the other hand, is connected with a specific contamination of air or water by sewage matter, and its secondary phenomena are developed generally in connexion with the digestive system. Hence a great prevalence of this disease was to be looked for in the warmer seasons, and more particularly at a time when the first autumn rains had washed into drinking wells, and other sources of water supply, the decomposing matters which had been innocuous so long as the skies were clear and the sun still high in the heavens.

APPENDIX I.

LIST OF SANITARY DISTRICTS IN IRELAND.

I.—URBAN SANITARY DISTRICTS.

1.—*Towns Corporate.*

(Arranged according to Population.)

	Area in Acres	Population	No. of Inhabited Houses	Rateable Value
				£
Dublin - -	3,808	246,326	23,896	596,099
Belfast - -	5,991	174,412	27,967	461,242
Cork - - -	2,266	78,642	10,390	—
Limerick. - -	2,075	39,353	5,518	100,364
Londonderry -	497	24,328	—	62,246
Waterford - -	533	23,349	3,557	—
Drogheda - -	454	13,510	2,958	27,360
Kilkenny - -	921	12,710	2,290	32,032
Sligo - - -	417	—	—	17,895
Wexford - -	483	12,077	2,127	15,068
Clonmel - -	331	10,112	1,323	15,112

2.—*Towns under 9th Geo. IV., cap.* 82.

(Arranged Alphabetically.)

	Area in Acres	Population	No. of Inhabited Houses	Rateable Value
				£
Armagh - -	1,092	8,946	1,482	15,640
Bandon - -	446	6,131	936	8,884
Enniskillen - -	129	5,906	853	10,896
Lisburn - -	239	7,876	1,295	15,770
Tralee - -	542	9,506	1,385	11,661
Youghal - -	345	6,081	1,070	9,537

The Public Health (Ireland) Act, 1874, includes in the description of Urban Sanitary Authorities (sec. 3, Table) "Towns the population of which exceeds 6,000, having Municipal Commissioners under 3 & 4

Vict., cap. 108." The only town in Ireland which is governed by Municipal Commissioners is Carrickfergus, and its population is only 4,212.

3.—*Towns under the Towns Improvement Act*, 1854.

(Arranged Alphabetically.)

	Area in Acres	Population	No. of Inhabited Houses	Rateable Value
				£
Athlone - -	1,294	6,566	1,093	7,691
Ballymena - -	472	7,931	1,403	—
Carlow - -	629	7,842	1,367	10,100
Carrick-on-Suir -	2,200	7,792	1,457	—
Coleraine - -	207	6,236	1,258	11,569
Dundalk - -	1,386	11,327	2,045	19,438
Dungarvan - -	1,357	6,520	1,224	15,490
Ennis - -	469	6,503	1,100	6,587
Fermoy - -	327	7,337	804	—
Kinsale - -	300	6,404	635	5,344
Lurgan - -	851	10,632	1,831	—
New Ross - -	458	6,772	1,120	7,730
Newry - -	701	13,364	2,315	28,546
Newtownards -	483	9,562	1,928	—
Portadown - -	654	6,735	1,336	—
Queenstown -	535	10,334	999	—

4.—*Towns and Townships having Commissioners under Local Acts.*

(Arranged Alphabetically.)

	Area in Acres	Population	No. of Inhabited Houses
Blackrock (Co. Dublin) -	1,084	8,089	1,447
Bray - - - - -	1,070	6,087	1,150
Clontarf - - - -	1,295	3,442	624
Dalkey - - - -	592	2,584	499
Galway - - - -	—	—	—
Kilmainham (Co. Dublin)	580	4,956	543
Kingstown - - -	920	16,378	2,784
Pembroke - - -	1,621	20,982	2,886
Rathmines and Rathgar -	1,529	20,562	3,105

II.—RURAL SANITARY DISTRICTS.

1.—*Rural Sanitary Districts consisting of Entire Unions.*

	No. of Dispensary Districts	Area in Acres	Population	No. of Inhabited Houses
Abbeyleix - - -	5	107,166	19,949	3,895
Antrim - - - -	6	117,127	35,928	7,091
Ardee - - - -	5	96,210	22,282	4,438
Athy - - - -	6	160,253	30,025	5,677
Bailieborough - - -	5	65,909	22,062	4,115
Ballina - - - -	2	150,145	30,911	—
Ballinasloe - - -	6	160,507	24,291	—
Ballinrobe - - -	4	144,895	29,276	—
Ballycastle - - -	3	102,197	18,507	3,755
Ballymahon - - -	3	100,126	18,788	3,734
Ballymoney - - -	5	127,518	38,505	—
Ballyshannon - - -	5	132,353	28,308	—
Ballyvaughan - - -	1	71,062	5,712	1,084
Balrothery - - -	6	75,289	20,066	4,241
Baltinglass - - -	4	139,113	20,403	3,765
Banbridge - - -	6	124,928	65,768	—
Bantry - - - -	3	106,854	16,330	2,692
Bawnboy - - -	4	104,504	24,006	—
Belmullet - - -	2	177,933	15,758	—
Borrisokane - - -	3	81,849	11,510	2,326
Boyle - - - -	5	159,696	43,991	—
Caherciveen - - -	5	197,545	25,148	4,457
Callan - - - -	4	104,010	20,764	4,057
Carrickmacross - -	3	60,664	20,642	—
Carrick-on-Shannon -	4	100,736	28,115	—
Cashel - - - -	5	156,821	29,392	5,308
Castlebar - - -	3	140,998	32,174	—
Castleblayney - - -	4	94,213	39,584	—
Castlecomer - - -	2	57,820	14,302	2,576
Castlederg - - -	2	91,785	16,311	—
Castlerea - - -	4	162,363	44,238	—
Castletown - - -	2	73,445	14,326	2,416
Cavan - - - -	8	160,662	53,558	9,964
Celbridge - - -	5	86,870	18,062	3,293
Claremorris - - -	3	110,788	31,300	—
Clifden - - - -	4	192,965	25,231	—
Clogheen - - -	3	118,426	22,247	3,774
Clogher - - - -	4	101,679	25,199	—
Clonakilty - - -	3	80,464	26,849	4,832

Rural Sanitary Districts—continued.

	No. of Dispensary Districts	Area in Acres	Population	No. of Inhabited Houses
Clones - - - -	3	73,502	23,567	—
Cookstown - - -	4	96,720	34,661	—
Cootehill - - -	4	105,848	34,831	—
Corrofin - - - -	1	61,386	7,095	1,311
Croom - - - -	3	83,323	17,061	3,152
Delvin - - - -	3	74,775	11,847	2,277
Dingle - - - -	5	125,278	20,245	3,499
Donaghmore - - -	2	51,059	8,359	1,551
Donegal - - - -	5	160,403	27,716	5,134
Downpatrick - - -	7	147,440	54,644	11,219
Dromore, West - -	3	96,986	17,742	—
Dunfanaghy - - -	2	125,677	16,477	3,021
Dungannon - - -	5	102,548	45,989	—
Dunmanway - - -	3	103,917	17,666	2,967
Dunshaughlin - - -	4	108,336	11,647	2,318
Edenderry - - -	6	172,383	20,160	3,878
Enniscorthy - - -	7	196,689	39,557	7,599
Ennistymon - - -	3	99,281	23,355	4,015
Glennamaddy - - -	3	100,319	29,274	—
Glenties - - - -	5	257,479	37,930	7,126
Glin - - - -	3	60,666	14,899	2,545
Gorey - - - -	4	129,704	23,209	4,358
Gort - - - -	3	107,919	17,973	—
Gortin - - - -	2	111,261	15,546	—
Granard - - - -	8	134,003	33,633	6,117
Inishowen - - -	5	159,411	38,374	6,616
Irvinestown - - -	3	75,927	19,642	—
Kanturk - - -	4	186,517	32,796	5,764
Kells - - - -	5	108,982	21,895	4,235
Kenmare - - -	4	198,152	18,348	2,896
Kilkeel - - - -	4	81,843	21,426	4,205
Killadysert - - -	2	62,319	12,211	2,137
Killala - - - -	2	104,882	10,242	—
Killarney - - -	6	251,286	44,443	7,221
Kilmacthomas - -	2	64,477	13,399	2,419
Kilmallock - - -	6	140,356	34,954	5,901
Kilrush - - - -	5	136,787	35,978	6,278
Larne - - - -	5	117,800	34,401	6,380
Letterkenny - - -	3	101,207	17,113	3,134
Lismore - - - -	4	97,140	18,834	3,262
Lisnaskea - - -	4	98,745	23,382	—
Listowel - - - -	4	151,208	34,283	5,511
Longford - - -	3	109,961	29,530	5,468
Loughrea - - -	4	198,832	26,402	—
Macroom - - -	5	179,108	30,544	5,325

Rural Sanitary Districts—continued.

	No. of Dispensary Districts	Area in Acres	Population	No. of Inhabited
Magherafelt - - -	5	156,721	58,747	—
Mallow - - - - -	6	154,357	31,112	5,363
Manorhamilton - -	4	144,847	30,667	—
Midleton - - -	6	109,265	30,404	5,680
Milford - - - - -	5	111,334	25,819	4,737
Millstreet - - -	2	74,905	14,592	2,449
Mitchelstown - - -	3	86,956	20,745	3,616
Mohill - - - - -	4	92,956	27,714	—
Monaghan - - -	5	112,379	37,017	—
Mount Bellew - - -	3	102,383	18,846	—
Mountmellick - - -	7	200,632	37,165	7,307
Mullingar - - -	7	208,400	36,837	7,012
Naas - - - - -	8	216,584	44,197	6,726
Navan - - - - -	3	94,465	19,311	3,853
Nenagh - - - - -	5	183,088	33,206	6,066
Newcastle - - -	5	143,023	30,196	5,148
Newport - - - -	3	170,413	16,061	—
Newtownlimavady - -	5	152,712	27,821	—
Oldcastle - - -	5	85,911	21,471	4,034
Omagh - - - - -	5	174,217	47,139	—
Oughterard - - -	3	172,745	19,607	—
Parsonstown - - -	7	118,487	20,034	3,942
Portumna - - -	3	77,046	12,906	—
Rathdrum - - -	8	227,540	37,807	6,920
Rathkeale - - -	4	79,931	17,884	3,354
Roscommon - - -	3	114,057	22,468	—
Roscrea - - - - -	3	118,488	20,034	3,942
Scariff - - - - -	3	86,320	13,953	—
Shillelagh - - -	3	110,121	17,857	3,218
Skibbereen - - -	4	115,023	31,385	5,391
Skull - - - - -	2	57,169	13,139	2,353
Strabane - - -	5	134,372	39,510	—
Stranorlar - - -	3	121,151	18,611	3,473
Strokestown - - -	3	90,036	23,345	—
Swineford - - -	5	152,594	53,540	—
Thomastown - - -	4	107,577	18,817	3,658
Thurles - - - - -	6	143,350	31,475	5,616
Tipperary - - -	6	179,987	42,931	7,167
Tobercurry - - -	3	125,774	26,724	—
Trim - - - - -	4	119,518	19,541	3,887
Tuam - - - - -	4	190,649	41,323	—
Tulla - - - - -	3	84,723	13,763	2,496
Tullamore - - -	5	155,394	28,420	5,710
Urlingford - - -	5	76,148	12,623	2,508
Westport - - -	4	175,508	24,765	—

2.—*Rural Sanitary Districts consisting of parts of Unions, of which other parts are Urban Sanitary Districts.*

(Arranged Alphabetically.)

	Area in Acres	Population	No. of Inhabited Houses
Armagh - - -	153,161	63,445	—
Athlone - - -	—	—	—
Ballymena - - -	160,689	63,534	—
Bandon - - -	100,898	19,608	3,437
Belfast - - -	42,381	28,229	4,933
Carlow - - -	185,225	38,093	7,349
Carrick-on-Suir - -	110,428	20,321	3,459
Clonmel - - -	86,371	13,977	2,504
Coleraine - - -	112,189	32,537	—
Cork - - -	166,930	54,403	8,799
Drogheda - - -	98,608	21,216	4,358
Dublin, North - -	38,056	21,973	3,373
Dublin, South - -	42,518	15,362	2,782
Dundalk - - -	13,048	34,074	—
Dungarvan - - -	92,687	15,349	2,730
Ennis - - -	112,035	20,027	3,529
Enniskillen - - -	203,499	—	—
Fermoy - - -	147,941	25,446	4,678
Galway - - -	—	—	—
Kilkenny - - -	110,022	18,483	3,577
Kinsale - - -	78,351	18,190	3,222
Limerick - - -	175,876	39,895	6,821
Lisburn - - -	119,631	51,838	10,182
Londonderry - -	143,499	34,430	—
Lurgan - - -	79,091	59,284	10,956
New Ross - - -	176,772	33,174	6,061
Newry - - -	137,272	58,715	11,927
Newtownards - -	93,407	38,669	7,841
Rathdown - - -	57,852	21,559	3,753
Sligo - - -	—	—	—
Tralee - - -	221,304	40,319	6,526
Waterford - - -	125,186	33,958	6,003
Wexford - - -	125,818	28,563	5,622
Youghal - - -	70,279	15,878	2,892

APPENDIX II.

SPECIAL REAGENTS FOR WATER ANALYSIS.

Lead Paper is prepared by soaking white bibulous paper in solution of lead acetate. Cut the paper when nearly dry into strips, and enclose them in a bottle with a small lump of "sesquicarbonate of ammonia" of the shops, wrapped in a fold of bibulous paper.

Water of Standard Hardness.—Place 2·29 grammes of pure colourless calc spar in an evaporating dish of about one quarter litre capacity. Pour over the mineral a little water, and add, drop by drop, pure, strong hydrochloric acid. The calc spar dissolves with effervescence, forming a solution of calcium chloride. The liquid is evaporated to dryness in the water-bath. Water is then added, and the solution again evaporated to dryness. It is necessary to repeat this evaporation several times, in order to ensure the removal of the excess of hydrochloric acid. But these operations must be conducted so as to avoid the slightest loss. The residue is finally dissolved in distilled water, and the solution poured through a funnel into a litre flask, the capsule and funnel are then repeatedly rinsed with water, and the rinsings received in the flask. The liquid is then made up to the bulk of a litre, and the whole well shaken, and then poured into a dry stoppered bottle, and labelled "Solution of 16° of Hardness."

Standard Soap Solution.—The following are Sutton's excellent directions for preparing this test:—Rub together in a mortar 150 parts of common lead plaster (*emplastrum plumbi*), and 40 parts of dry carbonate of potassium. When they are fairly mixed, add a little methylated spirit, and continue triturating until a uniform creamy mixture is obtained. Allow it to stand for some hours, then throw on a filter, and wash several times with methylated spirit. The strong solution of soap thus obtained must be diluted with a mixture of one volume of distilled water and two volumes of methylated spirit (considering the soap solution as spirit), until exactly 16 c. c. are required to form a permanent lather with 50 c. c. of water of standard hardness. The mode of conducting the operation is that

described in the text; but we will suppose that the operator finds the solution too strong. Suppose 50 c. c. of standard water uses up only 14 instead of 16 c. c. of soap solution, we dilute 1,400 c. c. with 200 c. c. of a mixture of two volumes of plain spirit and one of water, mix thoroughly together, and again determine the strength so as to make certain that exactly 16 c. c. are required for 50 c. c. of standard water. Though we would advise the medical officer to ascertain that his solutions are of the proper strength, he will probably find it much more convenient to purchase them ready standardised than to occupy time in preparing them as above described.

Nessler's Test Solution.—The following is Chapman's method of preparing the solution, and it has always afforded us the most satisfactory results:—Dissolve about 50 grammes of iodide of potassium in a small quantity of hot distilled water. Place the vessel containing the solution on the water-bath, and add a strong solution of bichloride of mercury until the red precipitate, which is formed, ceases to be re-dissolved. Filter, add to the filtrate about 120 grammes of potash in strong solution. Make up to a litre, and then add a small quantity (5 c. c. or so) of the bichloride solution. Allow to subside and decant the clear liquid for use. It is as well to keep the quantity required for immediate use in a small bottle, and only to open the stock bottle to replenish it, as the solution becomes a little thick if much exposed to the air. The object of the addition of the second quantity of bichloride is to make the solution clear at once. If it be not added, the test will appear to be clear, but will not remain so when added to an ammoniacal solution. Still, if the test, without this addition, be kept for a week or ten days, it will deposit a little, and is then as good as the solution to which the bichloride has been added.

Alkaline Permanganate Solution.—Dissolve 8 grammes of crystallised permanganate of potassium and 200 grammes of solid caustic potash in a litre of water. Boil the solution in a flask for half an hour, and then, on cooling, pour into a stoppered bottle.

Ammonia-Free Water.—Distilled water which does not give a trace of brownish yellow colour when about 2. c. c. of Nessler are added to a cylinderful of the water.

Standard Ammonia Solution.—Dissolve 1·574 grammes of pure, dry sal ammoniac (ammonium chloride) in one litre of water; mix thoroughly, and pour the mixture into a clean, dry bottle. Having

rinsed the measuring flask with ammonia-free water two or three times, draw off from the bottle with a pipette 100 c. c. of the sal ammoniac solution, and place in the cleaned flask. Next fill up the flask to the litre mark with ammonia-free water, and mix thoroughly. This solution now forms the standard ammonia solution, and contains ·00005 gramme of NH_3 in each cubic centimetre—or ·005 centigramme.

Standard Silver Solution.—Dissolve in a litre of water free from the slightest trace of chlorine 4·76 grammes of pure crystallised nitrate of silver, which has been roughly powdered and then pressed between folds of bibulous paper. 10 c. c. of this solution precipitate 1 centigramme of chlorine.

Iodide of Starch Solution.—Rub together in a mortar 2 grammes of iodine and 16 grammes of starch with sufficient water to make a paste. Put the pasty matter into a Florence flask, cork, and put in the water bath for two hours, taking care to occasionally shake and to wash down with a few drops of water any iodine that may sublime into the neck of the flask. Then fill the flask with boiling water, digest for half an hour longer, and dilute to about two litres with cold water, filter through paper, and standardise with the silver, as described in the text.

Special Apparatus.

1 Litre Flask.

1 $\frac{1}{2}$-Litre Flask.

1 $\frac{1}{4}$-Litre Flask.

A Burette, with glass-stoppered cock, to deliver 50 c. c. and graduated in $\frac{1}{5}$th c. c.

A Pipette, to deliver 100 c. c.

A Pipette, to deliver 50 c. c.

A 10 c. c. Pipette, graduated in $\frac{1}{10}$th c. c.

A 5 c. c. Pipette, graduated in $\frac{1}{10}$th c. c.

3 Thin glass hemispherical Capsules, measuring about a decimetre in diameter

Water-Bath.—This may consist of a common saucepan with a tinplate cover, perforated by a circular hole measuring about $\frac{2}{3}$ decimetres across, so as to support a glass capsule over the steam arising from water boiling in the saucepan.

A Retort Stand.

A Liebig's Condenser.

2 Stoppered Retorts capable of holding about $\frac{3}{4}$th litre.

3 Stoppered Cylinders, of clear white glass, about two decimetres high, and capable of holding slightly more than 200 c. c.

A Balance, capable of turning at 1 milligramme.

A Box of Gramme Weights, and the Subdivisions.

As the metrical system of measures of length, capacity, and weight, may not be familiar to some of our readers, we extract the following sketch of the relations of the different measures of the system from *Reynolds' Lectures on Experimental Chemistry*, page 7 :—

Take a neatly-planed stick, and cut from it a length measuring three feet, three inches, and three eighths (accurately 39·37 inches). This is now a *metre*, the unit of the metrical system of measures of length, and from which that of weight is very simply derived. This metre is divided into ten parts, each of which is called a *decimetre*, into a hundred parts, or *centimetres*, and into a thousand parts, or *millimetres*. Multiples of the metre have the Greek prefixes; thus a thousand metres is a *kilometre*. The measures of length are related to those of capacity and weight in an extremely simple way. Construct a cube of wood, measuring along every edge exactly one-tenth of a metre, or a decimetre. This bulk is the unit of measures of capacity, and is called a *litre*, which is subdivided into *decilitres*, *centilitres*, and *millilitres*. *A millilitre, or cubic centimetre of water, at a temperature of* 4° *Centigrade, or* 39·2° *Fahr., is taken as the unit of weight, and is called a gramme.* As a litre of water contains a thousand cubic centimetres, it follows that a litre of water weighs a thousand grammes, and this weight is called a *kilogramme*. Finally, the gramme is divided into *decigrammes*, *centigrammes*, and *milligrammes*. The following diagram gives the Rev. Professor Galbraith's convenient Synoptic Table of the Metric System :—

Units.

Metre—Litre—Gramme.

10000 times Myria. 1000 „ Kilo. 100 „ Hecto. 10 „ Deca		
	Unit.	
		Deci, - 10th part. Centi, - 100th „ Milli, - 1000th „

Testing for Arsenic in Wall Papers.

Scrape off a little of the green colouring matter (arsenite of copper), mix this with its own bulk of carbonate of sodium (the bicarbonate after heating in spoon over the spirit flame for a few minutes) and with a little powdered charcoal. Put the mixture into a narrow and dry test-tube, and then heat the bottom of the tube. If arsenic be present, the characteristic garlic odour is produced, and a mirror-like sublimate of the metallic arsenic obtained on the sides of the tube above the point heated. Instead of the sublimate of metal, a ring of crystals of the white oxide of arsenic is obtained if the tube contains much air.

The bluing action of ammonia on the green paper is not characteristic of *arsenite* of copper. Non-arsenical copper pigments are rendered blue by ammonia.

APPENDIX III.

Meteorological Tables.

Table 1.—*Tension, or Elastic Force, of Aqueous Vapour in inches of mercury for every degree of temperature from* 0° to 95°.

Temp.	Tension	Temp.	Tension	Temp.	Tension
°		°		°	
0	·044	32	·181	64	·596
1	·046	33	·188	65	·617
2	·048	34	·196	66	·639
3	·050	35	·204	67	·661
4	·052	36	·212	68	·684
5	·054	37	·220	69	·708
6	·057	38	·229	70	·733
7	·060	39	·238	71	·759
8	·062	40	·247	72	·785
9	·065	41	·257	73	·812
10	·068	42	·267	74	·840
11	·071	43	·277	75	·868
12	·074	44	·288	76	·897
13	·078	45	·299	77	·927
14	·082	46	·311	78	·958
15	·086	47	·323	79	·990
16	·090	48	·335	80	1·023
17	·094	49	·348	81	1·057
18	·098	50	·361	82	1·092
19	·103	51	·374	83	1·128
20	·108	52	·388	84	1·165
21	·113	53	·403	85	1·203
22	·118	54	·418	86	1·242
23	·123	55	·433	87	1·282
24	·129	56	·449	88	1·323
25	·135	57	·465	89	1·366
26	·141	58	·482	90	1·410
27	·147	59	·500	91	1·455
28	·153	60	·518	92	1·501
29	·160	61	·537	93	1·548
30	·167	62	·556	94	1·596
31	·174	63	·576	95	1·646

Table 2.—*Glaisher's Factors.*

Reading of the Dry-bulb Thermometer	Factor	Reading of the Dry-bulb Thermometer	Factor	Reading of the Dry-bulb Thermometer	Factor
°		°		°	
20	8·14	44	2·18	68	1·79
21	7·88	45	2·16	69	1·78
22	7·60	46	2·14	70	1·77
23	7·28	47	2·12	71	1·76
24	6·92	48	2·10	72	1·75
25	6·53	49	2·08	73	1·74
26	6·08	50	2·06	74	1·73
27	5·61	51	2·04	75	1·72
28	5·12	52	2·02	76	1·71
29	4·63	53	2·00	77	1·70
30	4·15	54	1·98	78	1·69
31	3·70	55	1·96	79	1·69
32	3·32	56	1·94	80	1·68
33	3·01	57	1·92	81	1·68
34	2·77	58	1·90	82	1·67
35	2·60	59	1·89	83	1·67
36	2·50	60	1·88	84	1·66
37	2·42	61	1·87	85	1·65
38	2·36	62	1·86	86	1·65
39	2·32	63	1·85	87	1·64
40	2·29	64	1·83	88	1·64
41	2·26	65	1·82	89	1·63
42	2·23	66	1·81	90	1·63
43	2·20	67	1·80	91	1·62

TABLE 3.—*For reducing Observations of the Barometer to Sea-level. (Barometrical Reading at Sea-level = 30 inches.)*

Height in Feet	Temperature—Fahr.						
	30°	40°	50°	60°	70°	80°	90°
	+ IN.	+ IN.	+ IN.	+ IN.	+ IN.	+ IN.	+ IN.
10	·012	·011	·011	·011	·011	·010	·010
20	·023	·023	·022	·022	·021	·021	·021
30	·035	·034	·033	·033	·032	·031	·031
40	·046	·045	·044	·043	·043	.042	·041
50	·058	·056	·055	·054	·053	.052	·051
60	·069	·068	·066	·065	·064	.063	·062
70	·081	·079	·077	·076	·075	·073	·072
80	·092	·090	·089	·087	·085	·084	·082
90	·104	·102	·100	·098	·096	·094	·092
100	·115	·113	·111	·109	·106	·104	·103
110	·127	·124	·122	·119	·117	·115	·113
120	·138	·135	·133	·130	·128	·125	·123
130	·150	·147	·144	·141	·138	·136	·133
140	·161	·158	·155	·152	·149	·146	·144
150	·173	·169	·166	·163	·160	·157	·154
160	·184	·180	·177	·173	·170	·167	·164
170	·196	·192	·188	·184	·181	·177	·174
180	·207	·203	·199	·195	·191	·188	·184
190	·218	·214	·210	·206	·202	·198	·195
200	·230	·225	·221	·217	·213	·209	·205
210	·241	·237	·232	·227	·223	·219	·215
220	·253	·248	·243	·238	·234	·229	·225
230	·264	·259	·254	·249	·244	·240	·235
240	·276	·270	·265	·260	·255	·250	·246
250	·287	·281	·276	·271	·266	·261	·256
260	·299	·293	·287	·281	·276	·271	·266
270	·310	·304	·298	·292	·287	·281	·276
280	·322	·315	·309	·303	·297	·292	·286
290	·333	·326	·320	·314	·308	·302	·297
300	·344	·338	·331	·324	·318	·312	·307

TABLE 3—*continued.* (*Barometrical Reading at Sea-level* = 27 *inches.*)

Height in Feet	Temperature—Fahr.						
	° 30	° 40	° 50	° 60	° 70	° 80	° 90
	+ IN.	+ IN.	+ IN.	+ IN.	+ IN.	+ IN.	+ IN.
10	·010	·010	·010	·010	·010	·009	·009
20	·021	·020	·020	·020	·019	·019	·018
30	·031	·031	·030	·029	·029	·028	·028
40	·041	·041	·040	·039	·038	·038	·037
50	·052	·051	·050	·049	·048	·047	·046
60	·062	·061	·060	·059	·058	·056	·055
70	·073	·071	·070	·068	·067	·066	·065
80	·083	·081	·080	·078	·077	·075	·074
90	·093	·091	·090	·088	·086	·085	·083
100	·104	·102	·100	·098	·096	·094	·092
110	·114	·112	·110	·107	·105	·103	·102
120	·124	·122	·119	·117	·115	·113	·111
130	·135	·132	·129	·127	·124	·122	·120
140	·145	·142	·139	·136	·134	·132	·129
150	·155	·152	·149	·146	·144	·141	·138
160	·166	·162	·159	·156	·153	·150	·148
170	·176	·172	·169	·166	·163	·160	·157
180	·186	·183	·179	·175	·172	·169	·166
190	·197	·193	·189	·185	·182	·178	·175
200	·207	·203	·199	·195	·191	·188	·184
210	·217	·213	·209	·205	·201	·197	·193
220	·227	·223	·219	·214	·210	·206	·203
230	·238	·233	·228	·224	·220	·216	·212
240	·248	·243	·238	·234	·229	·225	·221
250	·258	·253	·248	·243	·239	·234	·230
260	·269	·263	·258	·253	·248	·244	·239
270	·279	·273	·268	·263	·258	·253	·248
280	·289	·283	·278	·272	·267	·262	·258
290	·299	·293	·288	·282	·277	·272	·267
300	·310	·303	·298	·292	·286	·281	·276

TABLE 4.—*Corrections to be subtracted from the readings of Barometers*, with brass scales *extending from the cistern to the top of the mercurial column, to reduce the observations to 32° Fahrenheit.*

Temp.	Inches						
	28	28·5	29	29·5	30	30·5	31
°							
29	·001	·001	·001	·001	·001	·001	·001
30	·004	·004	·004	·004	·004	·004	·004
31	·006	·006	·007	·007	·007	·007	·007
32	·009	·009	·009	·009	·009	·010	·010
33	·011	·012	·012	·012	·012	·012	·012
34	·014	·014	·014	·015	·015	·015	·015
35	·016	·017	·017	·017	·018	·018	·018
36	·019	·019	·020	·020	·020	·021	·021
37	·021	·022	·022	·022	·023	·023	·024
38	·024	·024	·025	·025	·026	·026	·026
39	·026	·027	·027	·028	·028	·029	·029
40	·029	·029	·030	·030	·031	·031	·032
41	·031	·032	·033	·033	·034	·034	·035
42	·034	·034	·035	·036	·036	·037	·037
43	·036	·037	·038	·038	·039	·040	·040
44	·039	·040	·040	·041	·042	·042	·043
45	·041	·042	·043	·044	·044	·045	·046
46	·044	·045	·045	·046	·047	·048	·049
47	·046	·047	·048	·049	·050	·051	·051
48	·049	·050	·051	·052	·052	·053	·054
49	·051	·052	·053	·054	·055	·056	·057
50	·054	·055	·056	·057	·058	·059	·060
51	·056	·057	·058	·059	·060	·061	·062
52	·059	·060	·061	·062	·063	·064	·065
53	·061	·063	·064	·065	·066	·067	·068
54	·064	·065	·066	·067	·068	·070	·071
55	·066	·068	·069	·070	·071	·072	·073
56	·069	·070	·071	·073	·074	·075	·076
57	·071	·073	·074	·075	·076	·078	·079
58	·074	·075	·077	·078	·079	·081	·082
59	·076	·078	·079	·080	·082	·083	·085
60	·079	·080	·082	·083	·085	·086	·087
61	·081	·083	·084	·086	·087	·089	·090
62	·084	·085	·087	·088	·090	·091	·093
63	·086	·088	·089	·091	·093	·094	·096
64	·089	·090	·092	·094	·095	·097	·098
65	·091	·093	·095	·096	·098	·100	·101

Table 4—*continued.*

Temp.	Inches						
	28	28·5	29	29 5	30	30·5	31
°							
66	·094	·096	·097	·099	·101	·102	·104
67	·096	·098	·100	·102	·103	·105	·107
68	·099	·101	·102	·104	·106	·108	·109
69	·101	·103	·105	·107	·109	·110	·112
70	·104	·106	·108	·109	·111	·113	·115
71	·106	·108	·110	·112	·114	·116	·118
72	·109	·111	·113	·115	·117	·119	·120
73	·111	·113	·115	·117	·119	·121	·123
74	·114	·116	·118	·120	·122	·124	·126
75	·116	·118	·120	·122	·125	·127	·129
76	·119	·121	·123	·125	·127	·129	·131
77	·121	·123	·126	·128	·130	·132	·134
78	·124	·126	·128	·130	·133	·135	·137
79	·126	·128	·131	·133	·135	·137	·140
80	·129	·131	·133	·136	·138	·140	·143
81	·131	·134	·136	·138	·141	·143	·145
82	·134	·136	·138	·141	·143	·146	·148
83	·136	·139	·141	·143	·146	·148	·151
84	·139	·141	·144	·146	·149	·151	·154
85	·141	·144	·146	·149	·151	·154	·156
86	·144	·146	·149	·151	·154	·156	·159
87	·146	·149	·151	·154	·157	·159	·162
88	·149	·151	·154	·157	·159	·162	·165
89	·151	·154	·156	·159	·162	·165	·167
90	·153	·156	·159	·162	·164	·167	·170

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